FOLIA OECOLOGICA – vol. 43, no. 2 (2016). ISSN 1336-5266

Detailed mapping of geocomplexes in the vineyard landscape

Vladimír Falťan[1*], Lenka Pírová[2], František Petrovič[3]

[1]Department of Physical Geography and Geoecology, Faculty of Natural Sciences, Comenius University in Bratislava, Mlynská dolina, Ilkovičova 6, 84215 Bratislava 4, Slovak Republic
[2]Agricultural Paying Agency, Dobrovičova 12, 81526 Bratislava, Slovak Republic
[3]Department of Ecology and Environmental Sciences, Faculty of Natural Sciences, Constantine the Philosopher University in Nitra, Trieda A. Hlinku 1, 94974 Nitra, Slovak Republic

Abstract
Falťan, V., Pírová, L., Petrovič, F., 2016. Detailed mapping of geocomplexes in the vineyard landscape**.** *Folia Oecologica,* 43: 138–146.

Viticultural landscape is a valuable part of the cultural landscape – it was created by the long-term impact of human activities on the areas with suitable environmental conditions for the development of vineyards. A geoecological research within an example study of vineyard landscape was realised in choric and topical geographical dimension in the Doľany vicinity. Georelief was selected as a leading factor of regionalisation at the level of geochores. Information about soil-forming substrates and land cover on a topical dimension was specified within a detailed research of the terrain. Overall, five basic types of geochores and 58 types of geoecological complexes were earmarked. The most frequent occurrence of vineyards was on the alluvial cones and slopes of the Malé Karpaty Mts. As a part of the detailed research of the soil, we further characterized location conditions of different grape varieties in the Fosandle and Grefty localities.

Key words
Doľany, geoecological research, Slovakia, vineyard landscape

Introduction

Detailed research of agricultural landscape is still an actual topic of landscape ecology. Human impact has been changing the landscape for centuries. Landscape changes are an expression of the dynamic interaction between natural and cultural forces in the environment (Antrop, 2005). These changes significantly affect the landscape's ecological stability (Lipský, 2001; Ivan et al., 2015), as well as biological (Löfvenhaft et al., 2004), environmental and aesthetic value (Nassauer, 1995; Pătru-Stupariu et al., 2015). In Central Europe, agricultural processes belong to important drivers of the land use changes (Muchová and Petrovič, 2010; Špulerová et al., 2011; Kopecká et al., 2012; Jusková and Muchová, 2013; Opršal et al., 2013; Havlíček et al., 2014; Jusková and Muchová, 2014; Sklenička et al., 2014; Grešlová et al., 2015; Lieskovský et al., 2015).

Viticultural landscape is a valuable part of the cultural landscape – it was created by the long-term impact of human activities on areas with suitable environmen-

*Corresponding author:
vladimir.faltan@uniba.sk

tal conditions for the development of vineyards (Supuka et al., 2011). Viticultural landscape has a remarkable landscape image, the importance for ecological stability and physiognomically it is a distinctive type of land cover. Environmental conditions also form a significant part of the terroir.

The term ´terroir´ is used very often globally, and it means the influence of natural factors, especially concerning geology, soils, relief and climate, suitable vine variety for the site and also the technological procedures of wine makers. Studying various parameters of terroir altogether is very rare and has become a subject of interest (van Leeuwen et al., 2004). Over the past few years, geographic information systems have been used for the accurate mapping of vineyards (Matečný, 2014). In this context, modelling of relief indices for spatial differentiation of microclimatic conditions has also played an important role (Miklós et al., 1991; Matečný et al., 2010). Modern complex physical geographical (geoecological) research is focused on a detailed description of formation, evolution, and operation of geosystems at a detailed topic level, with relevant landscape components being represented (Minár, 2003; Falťan et al., 2009; Čech and Kunáková, 2012; Bartík et al., 2014). Many Slovak wine producers are aware of the importance of terroir and are endeavouring to produce wines from grapes that are bound to a specific locality. Therefore more attention has been paid to parameters such as bedrocks, soils and climate in vineyards (Ďörď et al., 2010).

Over the last few years, the quality of Slovak wine has improved; as confirmed by the many gold medals won at various prestigious wine competitions around the world. Slovak wine is now comparable to fine world wines in terms of its quality and sensorial properties. On the other hand, vineyard areas are still being reduced (Lauko et al., 2013; Hanušin and Štefunková, 2015). The wine region of the Malé Karpaty Mts has very good soil, climate and ecological conditions for wine production (Čerňanský and Kuhn, 2012). Yet vineyards are being abandoned in this region because of the current EU Agricultural policy (Lieskovský et al., 2013). Viticulture participates in the conservation and appropriate usage of agricultural soils, and in the evolution of ecologically balanced land with economic benefits.

The objective of our research is to investigate geosystems (with relevant natural components of terroir) in the surroundings of the vineyard village Doľany in the wine region of the Malé Karpaty Mts. We will use the methodology of geoecological research and detailed mapping in both choric and topic geographical dimensions. Maps of choric dimension characterize wider (horizontal) relationships in the vineyard landscape, while research in topical dimension yields basic information on natural components of terroir in large scale and their spatial distribution.

Material and methods

Study area

The investigated area in the surroundings of Doľany (Fig. 1) occupies the foot of the slopes of the Malé Karpaty Mts with adjacent highland belonging to the Podunajská nížina lowland. It is an area with a significant history of grape growing. The investigated area covers 1,196.16 ha and is located between 188 and 472 m asl. The vineyards in Doľany, belonging to JM Vinárstvo Doľany (where detailed field research was carried out), cover an area of 7.56 ha and are located at the foot of Malé Karpaty at the boundary of cadastral areas of the boroughs Doľany and Dolné Orešany, at an altitude of 236 to 256 m asl.

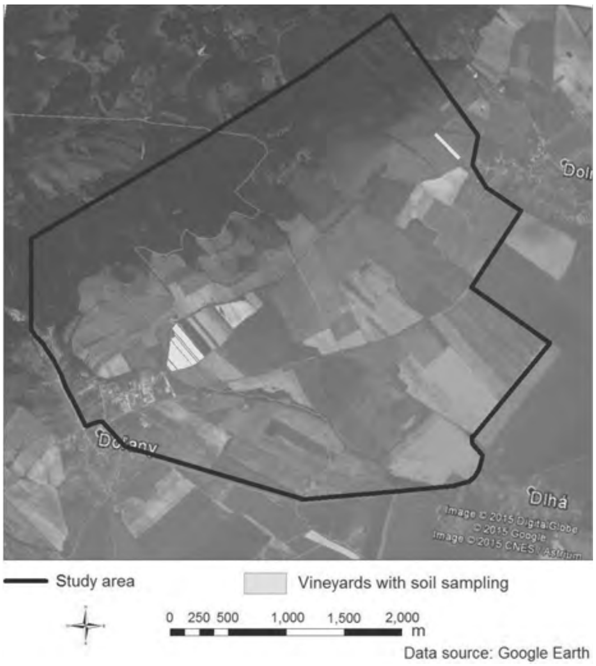

Fig. 1. Localization of study area.

Doľany, sometimes also called Ompitál by the locals, was one of the oldest German colonies under the Malé Karpaty Mts, up to the first half of the 18th century, when people started to use the Slovak language. Since 1608, Doľany has been an important wine town. Wine trade, which was dependant on the area of vineyards and the grape harvest, was especially important for the development of the town. According to the data from 1858, the vineyards occupied 98.5 ha of the total 2,206 ha belonging to the borough. White grape varieties Cirifandl and Lampart were grown there. At the end of the 19th century, vine phylloxera spread throughout the wine region, resulting in the loss of the vineyard area in the following years. In 1924, during the interwar period, the area of vineyards was only 21 ha. After

World War II, the price of wine had increased, which resulted in the expansion of viniculture. In 1950s, the collectivisation caused not only the change of the wine grape land ownership, but also influenced the level of viniculture. The co-operative viniculture shifted from growing hybrids to growing varieties such as Grüner Veltliner, Irsay Oliver, Burgundy, Silvaner. The change of situation after the fall of communism was manifested by initially good results – in 1992, the 89 ha of vineyards produced an average yield of 5.21 tons of grapes per hectare. In the following years, the wine production decreased, which was resolved again in 1996 by leasing the co-operating vineyards to private entrepreneurs (Dubovský et al., 2002).

Geoecological research and mapping of geosystems

The geosystems research consisted of several stages – the preparatory phase, field research and the final phase. The research process was based on the geological methodology according to the works of Minár et al. (2001) and Čech and Kunáková (2012), with emphasis on mapping in large scale.

The preparatory phase of the research consisted of collecting data and studying available materials around the observed area and its surroundings. The basemaps were studied for each relevant component of the country. The basemap of the lithology of the observed area was the Geological map of the Slovak Republic at scale of 1:50,000, available on the website of the State geological institute of Dionýz Štúr, and an additional source was a regional geological map (Polák et al., 2011). The basemap for the georelief characteristic was The Basic map of the Slovak Republic at 1:10,000. On the basis of contour lines, we have determined elementary forms of relief, to which the attributes according to the legend of the morphografic-positional types of relief have been assigned (Tremboš in Minár et al., 2001). In the case of transport slopes, attributes were extended to direct transport slope, concave transport slope and convex transport slope, from the viewpoint of the curvature contour line. The digital elevation model was created from the contour map by the tool Topo to raster with the size of the cell 10 m in the ArcGis environment. Other rasters of slope, aspect and insolation of land were derived from the digital model of relief.

Agriculturally used soils were characterized on the basis of the map service of the National Agriculture and Food Centre, through maps of evaluated soil-ecological units at a scale of 1:5,000 (Soil Portal, 2015). In forest areas, the data were derived from the WMS service of the National Forest Centre (2015). To unify the soil classification from these sources, a comparison of National Forest Centre soil systematic with the Morphogenetic classification system of soils of Slovakia was used. The information about climate characteristics was provided by the Slovak Hydrometeorological Institute for the period 1981–2010, from the stations, located nearest to examined locations. The average monthly rainfall totals were processed from the rain gauge stations in Dolné Orešany for the period 1981–2010. Similar data about air temperature in Doľany in 2014 were provided by the vine-dresser of wine-making JM Vinárstvo Doľany, which was compared with the average air temperature at the station in Slovenský Grob in 2014. Aerial scans by Google Earth from 2013 were used to characterize land cover. Particular classes of land cover were assigned on the basis of the edited methodology and CORINE land cover legend at the 4th hierarchical level at a scale of 1:50,000 according to authors Feranec and Oťaheľ (1999). Land use of the examined area was mapped at a scale of 1:10,000, therefore we set the minimal size of the mapped area to 0.1 ha. Because the work was focused on vineyard landscape, two classes of land cover evolved from the original methodology (used and unused vineyards). In the further stages of research, we concentrated on mapping habitat conditions in the earmarked categories of vineyards. Potential natural vegetation was presented according to the map of potential natural vegetation (Maglocký in *Atlas krajiny*, 2002).

In terms of methodology by authors Falťan et al. (2011), a map of geocomplexes at the level of geochores was created for the whole examined territory, meaning that relatively homogenous areas where the horizontal relationships among geotopes and their groups were examined (Mičian, 2008), with an interpretation measure of 1:10,000. In our case, as a leading factor of regionalization, georelief at the level of mezoform was selected. Furthermore, information about the bedrock, soil type and subtype, relief insolation and potential natural vegetation was examined.

The realization of detailed field geoecological research was limited by the availability of particular vineyards, subject to the various owners and unsettled owner relationships. Our research was conducted on estates belonging to the JM Vinárstvo Doľany. Particular research points and borders of the examined vineyards were localized by a GPS device. During our research, the data gathered in the preparatory phase of research were verified. By characterization of pedosphere, the soil unit and soil category were set (soil type and subtype). Thickness, granularity, soil skeleton, composition, size and form of skeleton, colour, spottiness, humidity, hardness, plasticity, structure and biological activity were set for each horizon. Moreover, samples from depths of 20–40 cm and 50–70 cm were taken from particular soil probes for chemical testing, to find the content of carbonates (titration method), nitrogen (Kjeldahl method) and pH reaction (STN ISO 10390). Concerning georelief characteristics, information about GPS location, altitude of each point, slope, orientation, meso-form of georelief, genesis, age and process demonstrations was presented. The biosphere characteristic was set through real phytocenosis, potential phytocenosis, coverage and height in particular etages. Laboratory soil analyses were realized by the accredited laboratory of the Soil Fertility and Conservation Research Institute.

In the final phase of research, we concentrated on the creation of final maps of geochors types as well as types of geoecological complexes and insolation. By processing the results from our field research, we created a map of edited soil types and subtypes over the area of the examined vineyards. The results of the soil analyses and the data provided by vine-dressers were statistically processed in MS Excel. Relief insolation maps were created from the digital relief model using an Area Solar Radiation tool every half hour, each 14th day of the year. Random settings (except for the setting of the diffuse model type) were allowed in the parameters of insolation (the chosen option was most commonly overcast). The outputs of the detailed research were processed in the ArcGIS 10 Environment.

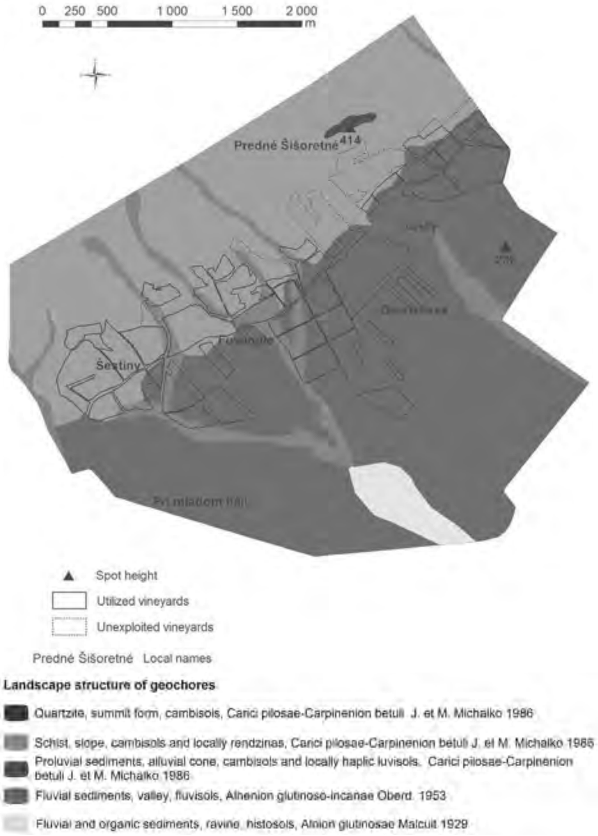

Fig. 2. Landscape structure of geochores.

Results

The examined area contains five types of geochores, illustrated in Fig. 2. The dominant areal representation has geochore of the alluvial cones on proluvial sediments where Cambisols have formed, and potential natural vegetation is represented by Carpathian oak-hornbeam forests. More than half of the vineyards (57.7%) in the examined area are located on this geochore. A large percentage of vineyards (37.7%) is situated on the geochore of slopes that consist mainly of shist where Cambisols have formed and potentially natural vegetation is created by Carpathian oak-hornbeam forests. Some vineyards extend to both of the mentioned geochores, particularly to the valley geochore. It follows that vineyards are most often located on alluvial cones, transport and foot slopes of the Malé Karpaty Mts. The larger slope and mainly south-eastern orientation of the relief influences the incoming solar radiation power. Solar radiation is an important positioning factor. Relief insolation in the Doľany area is presented in Fig. 3, where the average insolation value is 1,082.9 kWh/m^2 per year. The areas with the lowest incoming solar radiation power are in particular north-eastern and eastern valleys slopes and slopes with a western exposition; on the contrary the highest values of insolation occur on the south-western oriented slopes with a larger angle. In the study area, the slopes with south-eastern orientation outweigh the cardinal points overall. The vineyards extend over an area with insolation values from 1,026.4 to 1,168.9 kWh/m^2 per year. High insolation values were reported at vineyards, not in use, as well as in some south oriented localities with steeper slopes on forest land.

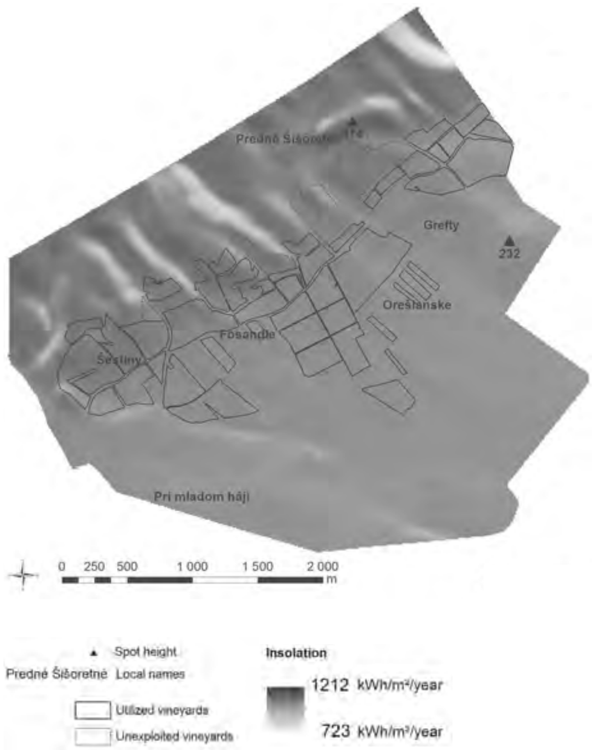

Fig. 3. Insolation of relief.

The results of the geotopes research were processed for the areas of vineyards. Together, under the framework of 6 types of geochors, 58 types of geoecological complexes were classified by using the georelief as the leading factor of regionalization; the most commonly represented are listed in Table 1. From the viewpoint of localization of vineyards, these complexes have beneficial assorted substrate, which contains worked aluminous and sandy gravels and aluminous-chiselly down-slopes. The substrate was the basis for forming the medium to hard skeleton soils, which is important for the wine grape, mainly when taking nutrients from the soil. A very important criterion is the ease of availability to these vineyards when in need of cultivation. On the contrary, the types of geoecological complexes that have good substrate potential and high insolation of 1,125.1 to 1,175 kWh m^{-2} per year (in the 5th and 6th categories of insolation), have not been used recently as vineyards, mainly because of their poor availability.

Table 1. The most frequent types of geosystems

Code	Lithological complex	Landform	Insolation category	Soil type	Area (%)
55	Proluvial sediments	Cone	2	Cambisol	25.86
56	Proluvial sediments	Cone	3	Cambisol	20.69
45	Deluvial sediments	Foot slope	3	Cambisol	12.07
46	Deluvial sediments	Foot slope	4	Cambisol	8.62
42	Proluvial sediments	Foot slope	4	Cambisol	6.19
51	Fluvial sediments	Floodplain	2	Fluvisol	6.90
04	Breccias and conglomerates	Erosion-denudational slope	4	Rendzina	5.17

The field research connected with sample collection at the examined area in Doľany was realized in vineyard localities Fosandle and Grefty (Fig. 4). The vineyard is located on an alluvial cone at an altitude between 236 and 256 m asl with a south-eastern exposition. The slope angle is from 1º to 7º. Geological bedrock is created by proluvial sediments, loamy and sandy gravels lay in the form of alluvial cones. According to the map of bonited soil-ecological units, there are Eutric Cambisols up to Luvi-Eutric Cambisols and Sagni-Haplic Luvisols in the examined vineyard. By using field research, we found an occurrence of cultivated Cambisols, Hortic Cambisols and cultivated Haplic Luvisols. At research points no. 1 and no. 2, cultivated Haplic Luvisols occur, Akp-horizon is present at a thickness of 35 cm, while no skeletons occur here, and the soils have loamy granulity. The dominant subsurface Bt-horizon contains up to 10% of skeletons and is enriched by translocated elements. Temporary B/C-horizon passes to bright substrate C-horizon (Fig. 5).

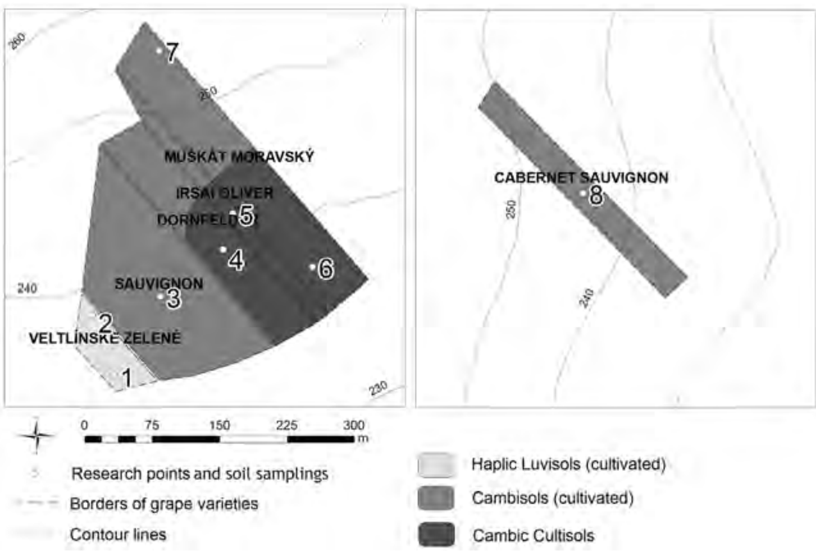

Fig. 4. Example of detailed soil map and localization of soil samples.

Fig. 5. Haplic Luvisol – soil sample no 1.

Table 2. Short description of chosen tesserae

No	1	2	3	4	5	6	7	8
Landform	Foot slope							
Substrate	Proluvial sediments							
Slope angle (°)	1–2	1–2	2–4	3–4	3–4	4–5	5–6	4–5
Soil type	Haplic Luvisol		Cambisols (cultivated)					
pH	7.09	7.03	6.72	7.41	7.01	7.29	7.37	7.05
Carbonates (%)	under 0.01							
Nitrogen (%)	0.03	0.02	0.01	0.02	0.04	0.02	0.02	0.01
Vine variety	Grüner Veltliner		Sauvignon	Dornfelder	Irsai Oliver	Moravian Muscat		Cabernet

At research point nos. 4–6, Hortic Cambisols occur, with a dominant Akm-horizon, the skeletal content is from 25 to 70% and loamy granulity. Under the cultisoil horizon, the cambic Bv-horizon is located with high skeletal content (70–80%), which passes to substrate C-horizon. At research point nos. 3, 7 and 8, cultivated Cambisols occur. The cultisoil Akp-horizon has up to 30% of skeleton and loamy granulity. The dominant cambisoil Bv-horizon has a high content of skeletons (up to 70%) and loamy granulity. The sample of basic characteristics discovered in field research is listed in Table 2. In the vineyard area in Doľany, neutral soils occur – the pH value moves from 6.72 to 7.41. The content of nitrogen in the soil moves from 0.01 to 0.04%. The volume of nitrogen in the soil is low and medium. Appropriate nutrition will complement fertilization at poorer areas. The content of carbonates in the examined samples is less than 0.01%. Carbonate content in the soil is low due to site conditions, but overall the site is suitable for growing vines.

Discussion

Landscape-ecological parameters characterising the landscape structure, function and dynamics play an important role as an indicator of sustainable development (Kozová and Pauditšová, 2001). Agricultural geosystems belong to important parts of the present landscape structure. Growing permanent crops significantly affects the character of the landscape and creates a specific type of cultural landscape. The huge changes that our society and viniculture, went through after World War II posed a threat to the traditional vineyard landscape. The significant changes are not only in the area, size and vineyard agronomical practices – or the residential pressure of large cities such as Bratislava or Nitra – but also the changing lifestyle of young generations, who do not seem to be interested in viniculture or agriculture at all (Lieskovský et al., 2013). The complex safety of the vinicultural landscape should include soil safety, in an attempt to optimize the way the landscape is used and to be able to minimize soil erosion (Dobos et al., 2014).

Intensive land use changes affect not only the country itself but also progressively limit the activities of man. Man is presently the dominant factor in the forming of landscape and adapts it to its goals. Our work focussed on the physio-geographical aspects of the terroir, presenting an important factor of the localization of vineyards. The geographical characteristic of a particular location gives the vine a specific taste, which differs from vines produced in other regions. Therefore, the geographical attitudes to the study of viniculture, with an emphasis on terroir, are nowadays actual topics (Bonfante et al., 2011; Dougherty et al., 2012). The field research and application of GIS tools is an important part of the study of vinicultural geosystems. By creating a preliminary geoecological map, we needed to choose appropriate base maps, or to create our own one by employing various methodologies (e.g. the map of elementary forms of relief). The methodology of creating the map of geosystems was influenced by the work of authors Minár et al.(2001); Čech and Kunáková (2012). These authors use the methods of the leading factor of georelief and the use of analytical maps within geoecological research and the locating of geotopes. In our research, georelief was chosen as the main factor. We filled the created areas with further important information from the viewpoint of terroir – mainly bedrock, soil type and subtype and surface relief radiation.

Similar methods are successfully applied abroad, in countries with a long-lasting experience of wine cultivation. The area analysis of terroir in Valle Tellesina (southern Italy), has been evaluated by authors Bonfante et al. (2011). The terroir was classified on the basis of soil, value of radiation, index of crop water stress and detailed climatic research. The resulting terroir units were defined according to the suitability of vine production. The problems encountered were also analysed by Carey et al. (2008) in the Stellenbosch area in The Republic of South Africa. They defined the natural terroir units on the basics of the relatively homogenous characteristics of the topography, clime, geology and soils. As the leading factor, the morphographical characteristics of surface relief (altitude, slope, orientation) and soil type were used.

Generally, the bedrock of the soil only has an indirect impact on the quality of grapes and vine. Often bedrock is almost covered by the dominancy of the soil, topographic and climatic characteristics. The majority of nutrients are gained from depths of up to 0.6 m and water from depths of up to 2 m (Huggett, 2005). The investigation of soils under impact of traditional agricultural activities is an important topic of landscape ecological research (Slámová et al., 2015). Detailed field research and sample taking of terroir is necessary. According to our research, we found differences between the data from official basis soil maps and the real field environment. At the research area in the Doľany vineyards, according to bonited soil-ecological units, are where mainly Eutric Cambisols up to Luvi-Eutric Cambisols and Stagni-Haplic Luvisols are located. According to field research, the dominant occurrence of Cambisols has been proved, however, with the significant impact of cultivation. Cultivated Cambisols have been identified in three research points; more significant transformation by cultivating has been shown in the occurrence of Hortic Cambisols in three further research points. The change has been found only in the level of subtype in the location of Stagni-Haplic Luvisols – we identified Haplic Luvisols here, probably due to the soil cultivation and drainage. Within future research, it will be important to monitor microclimatic conditions of locations during long periods, except detailed soil analyses. For that, we need stationary research and placement of meteorological stations in the vineyards.

Conclusion

Basic relevant natural components of landscape representing physical-geographical aspect of terroir were described on the basis of detailed geosystems research in our work. Geoecological research within an example study of vineyard landscape was realised in choric and topical geographical dimension in the Doľany vicinity. Georelief was selected as a leading factor of regionalisation at the level of geochores. Information about soil-forming substrates and land cover on a topical dimension was specified within detailed research of the terrain. Overall, five basic types of geochores and 58 types of geoecological complexes were earmarked for location in the Doľany vicinity. The most frequent occurrence of vineyards was on alluvial cones and slopes of the Malé Karpaty Mts in terms of choric dimension. As part of a detailed research of soil, we further characterized location conditions of different grape varieties (Grüner Veltliner, Sauvignon, Irsai Oliver, Moravian Muscatel, Dornfelder, Cabernet Sauvignon) in the Fosandle and Grefty localities.

From the field research we found the occurrence of cultivated Cambisols, Hortic Cambisols and cultivated Haplic Luvisols with a predominantly neutral soil reaction and a nitrogen content of 0.04%. The application of our methodology provides useful information in terms of landscape and wine-growing practice. The most significant outputs include identification of different types of geocomplexes in the vineyard landscape. Combination of information about georelief, bedrock and soil cover in choric and topical dimension creates the basis for regionalisation and detailed identification of natural terroir units. With this, future research may take place focusing mainly on the study of the relationship between the physical and chemical properties of soil and microclimatic conditions of the habitat quality of the wine produced. A more detailed analysis of this issue would require the cooperation of several experts (oenologists, geochemists, etc.) from different disciplines. Analysis of natural landscape components and outputs in the form of geo-ecological maps can be used in environmental practice (landscape planning, evaluation of the carrying capacity of the landscape, evaluation of the potential or capacity of the landscape, etc.).

Acknowledgements

This work was supported by the Scientific Grant Agency of the Ministry of Education of Slovak Republic and Slovak Academy of Science under Grant VEGA 1/0421/16 Analysis of land cover changes in the context of environmental drivers. The authors thank the company "JM Vinárstvo Doľany" for supporting the field research.

References

Antrop, M., 2005. Why landscapes of the past are important for the future. *Landscape and Urban Planning,* 70: 21–34.

Bartík, M., Sitko, R., Oreňák, M., Slovik, J., Škvarenina, J., 2014. Snow accumulation and ablation in disturbed mountain spruce forest in West Tatra Mts. *Biologia, Bratislava*, 69, 11: 1492–1501.

Bonfrante, A., Basile, A., Langella, G., Manna, P., Terribile, F., 2011. A physically oriented approach to analysis and mapping of terroirs. *Geoderma*, 167–168: 103–117.

Carey, V. A., Saayman, D., Archer, E., Barbeau, G., Wallace, M., 2008. Viticultural terroirs in Stellenbosch, South Africa. I. The identification of natural terroir units. *Journal International des Sciences de la Vigne et du Vin*, 42 (4): 169–183.

Čech, V., Kunáková, L., 2012. Geologický výskum a geologická databáza (na príklade katastrálneho územia obce Kolinovce) [Geoecological research and geoecological database (casestudy: cadastral area of village Kolinovce)]. *Geografický Časopis*, 64: 29–46.

Čerňanský, S., Khun, M., 2012. Geochemické prostredie Malokarpatskej vinohradníckej oblasti – výber vinohradníckych rajónov [Geochemical environs of the Malé Karpaty wineyard region – selection of vineyard rayons]. In Jurkovič, Ľ., Slaninka, I., Ďurža, O. (eds.). *Geochémia 2012*. Bratislava: ŠGÚDŠ, SAGH & Univerzita Komenského v Bratislave, p. 16–17.

Dobos, A., Nagy, R., Molek, Á., 2014. Land use changes in a historic wine region and their connections with optimal land-use: a case study of Nagy-Eged Hill, northern Hungary. *Carpathian Journal of Earth and Environmental Sciences*, 9 (2): 219–230.

Dougherty, P.H., 2012. *The geography of wine: regions, terroir and techniques*. New York: Springer. 255 p.

Ďörď, L., Ložek, O., Hronský, Š., 2010. *Vplyv klimatických faktorov na kvalitu hrozna avína v modrokamenskom vinohradníckom rajóne* [Impact of climatic factors on grape and vine quality in the Modrý Kameň vineyard rayon]. Nitra: Slovenská poľnohospodárska univerzita. 103 p.

Dubovský, J., Prospechová, P., Turcsány, J., 2002. *Doľany*. Doľany: Obecný úrad, 214 p.

Falťan, V., Bánovský, M., Blažek, M., 2011. Evaluation of land cover changes afterextraordinary windstorm by using the land cover metrics: a case study on the High Tatras foothill. *Geografie*, 166 (2): 156–171.

Falťan, V., Katina, S., Bánovský, M., Pazúrová, Z., 2009. The influence of site conditions on the impact of windstorms on forests: the case study of the High Tatras foothills (Slovakia) in 2004. *Moravian Geographical Reports,* 17 (3): 44–52.

Feranec, J., Oťaheľ, J., 1999. Mapovanie krajinnej pokrývky metódou CORINE v mierke 1 : 50 000: návrh legendy pre krajiny programu Phare [Mapping of land cover at scale 1 : 50000: draft of the nomenclanture for the Phare countries]. *Geografický Časopis*, 51: 19–44.

Grešlová, P., Gingrich, S., Krausmann, F., Chromý, P., Jančák, V., 2015. Social metabolism of Czech agriculture in the period 1830–2010. *Acta Universitatis Carolinae, Geographica,* 50: 23–35.

Hanušin, J., Štefunková, D., 2015. Changes in vine-growing landscape diversity in the hinterland of Svätý Jur town in 1896–2011. *Geografický Časopis,* 67: 243–259.

Havlíček, M., Pavelková, R., Fragjer, J., Skokanová, H., 2014. The long-term development of water bodies in the context of land use: The case of the Kyjovka and Trkmanka river basins (Czech republic). *Moravian Geographical Records*, 22 (4): 39–50.

Huggett, J. M., 2005. Geology and wine: a review. *Proceedings of the Geologists' Association*, 117: 239–247.

Ivan, P., Jarabicová, M., Muchová, Z., 2015. Assessment of changes in landuse by coefficient of the ecological stability. *International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management*, *SGEM*, Book 5, Vol. 1: 73–80.

Jusková, K., Muchová, Z., 2013. Land consolidation as an instrument for land ownership defragmentation in the Czech Republic and Slovakia. In *MendelNet 2013. Proceedings of International PhD Students Conference, November 20th and 21th, Brno.* Brno: Mendelova univerzita, p. 444–448.

Jusková, K., Muchová, Z., 2014. Options and trends of land consolidation in the Czech and Slovak republics, with regard to common historical development of ownership and usage rights. *International*

Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, Book 5, Vol. 2: 471–478.

Kopecká, M., Vatseva, R., Feranec, J., Oťahel, J., Stoimenov, A., Nováček, J., Dimitrov, V. 2012. Selected changes of arable land in Slovakia and Bulgaria during the period 1990–2006. *Moravian Geographical Reports*, 20 (1): 43–54.

Kozová, M., Pauditšová, E., 2001. Evaluation of the landscape structure and its changes for Local agenda 21. *Ekológia (Bratislava),* 20, Suppl. 3: 36–44.

Lauko, V., Tolmáči, L., Križan, F., Gurňák, D., Cákoci, R., 2013. *Geografia Slovenskej republiky: humánna geografia* [Geography of the Slovak Republic. Human geography]. Bratislava : Geografika. 289 p.

Lieskovský, J., Bezák, P., Špulerová, J., Lieskovský, T., Koleda, P., Dobrovodská, M., Bürgi, M., Gimmi, U., 2015. The abandonment of traditional agricultural landscape in Slovakia – Analysis of extent and driving forces. *Journal of Rural Studies*, 37: 75–84.

Lieskovský, J., Kanka, R., Bezák, P., Štefunková, D., Petrovič, F., Dobrovodská, M., 2013. Driving forces behind vineyard abandonment in Slovakia following the move to a market-oriented economy. *Land Use Policy*, 32: 356–365.

Lipský, Z., 2001. *Monitoring changes in the cultural landscape*. Praha: ČZU Praha.

Löfvenhaft, K., Runborg, S., Sjögren-Gulve, P., 2004. Biotope patterns and amphibian distribution as assessment tools in urban landscape planning. *Landscape and Urban Planning*, 68: 403–427.

Maglocký, Š., 2002. Potenciálna prirodzená vegetácia 1 : 500 000 [Potential natural vegetation 1 : 500 000]. In *Atlas krajiny SR.* Bratislava: MŽP, Banská Bystrica: SAŽP, 2002, p. 114.

Matečný, I., 2014. Spatial identification of vineyards – a prerequisite for maintainting them as a part of the cultural landscape heritage. *Acta Environmentalica Universitatis Comenianae*, 22 (2): 26–41.

Matečný, I., Jenčo, M., Matečná, G., 2010. Sklon reliéfu ako súčasť kritérií pre plnenie environmentálne šetrných postupov v poľnohospodárstve Slovenskej republiky [Relief slope angle as a part of criterions for environmentally friendly processes in agriculture of the Slovak Republic]. *Acta Geographica Universitatis Comenianae*, 54 (1): 33–52.

Mičian, Ľ., 2008. *Všeobecná geoekológia* [General geoecology]. Bratislava: Geografika. 88 p.

Miklós, L., Matečný, I., Kozová, M., 1991. Interpretation of the morphometric relief indices for spatial differentiation of microclimatic conditions. *Ekológia (Bratislava)*, 10: 223–246.

Minár, J., 2003. Detailed physical-geographical (geoecological) research and mapping in the landscape ecology. *Ekológia (Bratislava),* 22: 141–149

Minár, J., Barka, I., Bonk, R., et al. 2001. *Geoekologický (komplexný fyzickogeografický výskum a mapovanie vo veľkých mierkach* [Geoecological (complex physiogeographical) research and mapping in large scales]. Bratislava: Geografika. 210 p.

Muchová, Z., Petrovič, F., 2010. Changes in the landscape due to land consolidations. *Ekológia (Bratislava)*, 29: 140–157.

National Forest Centre, 2015. *Map server.* National Forest Centre [cit. 2015-12-10]. http://lvu.nlcsk.org

Nassauer, J., 1995. Culture and changing landscape structure. *Landscape Ecology*, 10: 229–237.

Opršal, Z., Šarapatka, B., Kladivo, P., 2013. Land-use changes and their relationships to selected landscape parameters in three cadastral areas in Moravia (Czech Republic). *Moravian Geographical Reports,* 21 (1): 41–50.

Pătru-Stupariu, I., Stupariu, M. S., Tudor, C.A., Grădinaru, S.R., Gavrilidis, A., Kienast, F., Hersperger, A.M., 2015. Landscape fragmentation in Romania's Southern Carpathians: Testing a European assessment with local data. *Landscape and Urban Planning*, 143: 1–8.

Polák, M., Plašienka, D., Kohút, M., Putiš, M., Bezák, V., Filo, I., Broska, I., 2011. *Geologická mapa regiónu Malých Karpát v mierke 1 : 50 000* [Geological map of the Malé Karpaty Region in scale 1:50,000]. Bratislava: MŽP SR, Štátny geologický ústav Dionýza Štúra.

Sklenička, P., Janovska, V., Salek, M., Vlasak, J., Molnarova, K., 2014. The farmland rental paradox: extreme land ownership fragmentation as a new form of land degradation. *Land Use Policy*, 38: 587–593.

Slámová, M., Jakubec, B., Hreško, J., Belaček, B., Gallay, I., 2015. Modification of the potential production capabilities of agricultural terrace soils due to historical cultivation in the Budina cadastral area, Slovakia. *Moravian Geographical Reports,* 23 (2): 47–55.

Soil Portal, 2015. *Evaluated soil-ecological units.* National Agriculture and Food Centre [cit. 2015-11-12]. http://www.podnemapy.sk/bpej

Špulerová, J., Dobrovodská, M., Lieskovský, J., Bača, A., Halabuk, A., Kohút, F., Mojses, M., Kenderessy, P., Piscová, V., Barančok, P., Gerhátová, K., Krajčí, J., Boltižiar, M., 2011. Inventory and classification of historical structures of the agricultural landscape in Slovakia. *Ekológia (Bratislava)*, 30: 157–170.

Supuka, J., Verešová, M., Šinka, K., 2011. Development of vineyards landscape structure with regard to historical and cultural values. *Ekológia (Bratislava)*, 30: 229–238.

Van Leeuwen, C., Friant, P., Chone, X., Tregoat, O., Koundouras, S., Dubordieu, D., 2004. Influence of climate, soil, and cultivar in terroir. *American Journal of Enology and Viticulture,* 55: 207–217.

Received April 18, 2016
Accepted May 9, 2016