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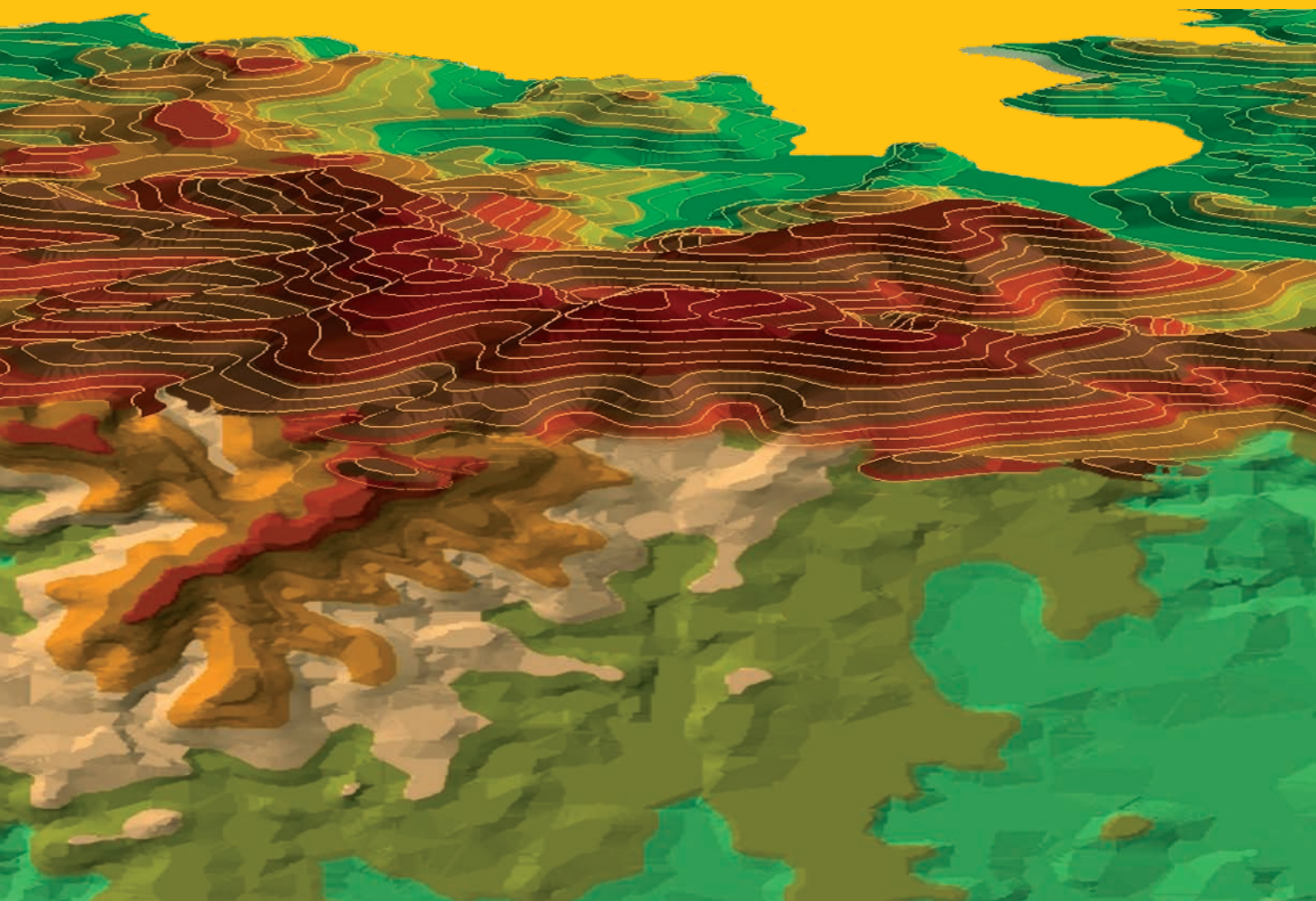

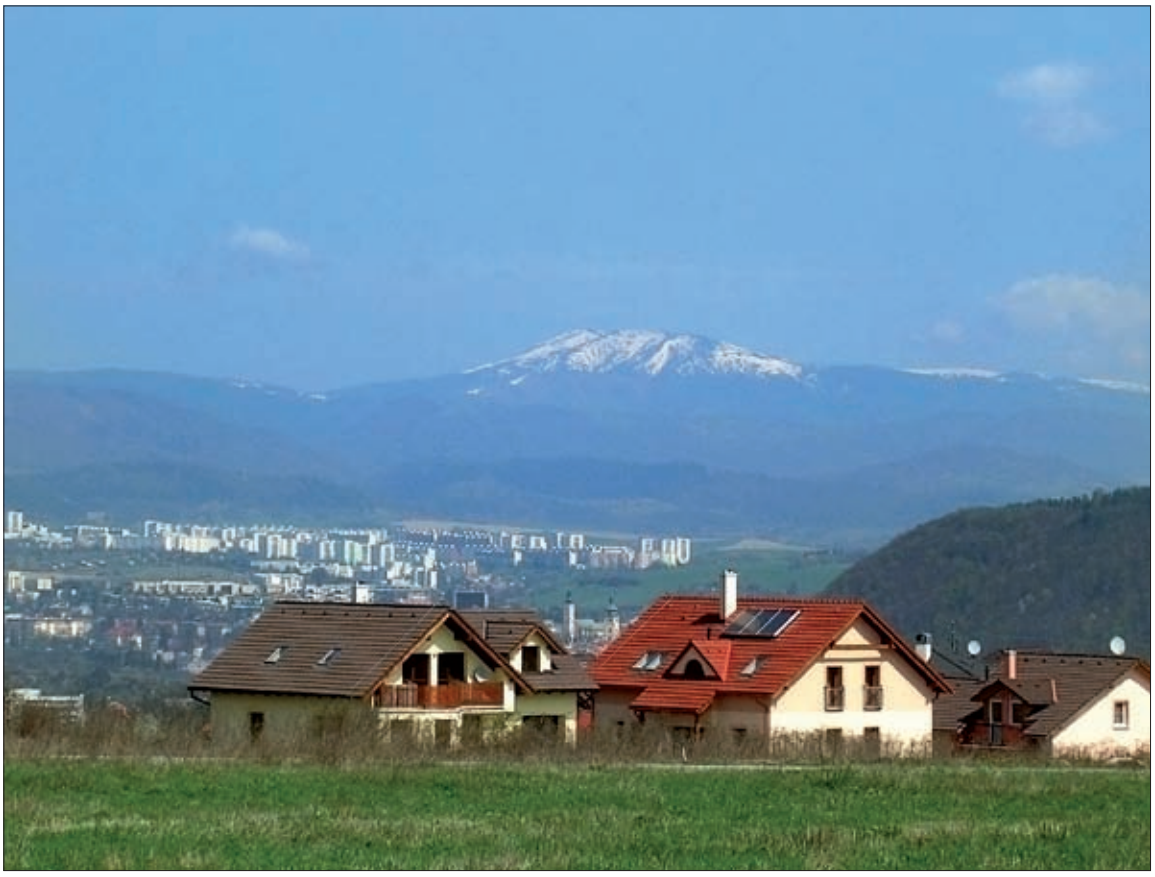

Fig. 5: Pršianska terasa became one of the most favorite locations of the residential built-up areas within the administrative borders of the town Banská Bystrica. Locality is one of the examples of the use of free plots on the green-fields (Photo Daniela Vigašová, 2008)

Fig. 6: New residential built-up area serves new elements in the rural countryside, such as: high cover with built-up area; various architecture; high fences or (and) blind street net. These features of new area spoils the former image of the rural settlements (Photo Martin Šveda, 2009)

Illustrations related to the paper by D. Vigašová, L. Papajová-Majeská, L. Krížová and M. Šveda

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MAILING ADDRESS

MGR, Institute of Geonics ASCR, v. v. i.
Drobného 28, 602 00 Brno, Czech Republic
(fax) 420 545 422 710
(e-mail) geonika@geonika.cz
(home page) http://www.geonika.cz

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WELLNESS TOURISM IN SLOVAKIA

Jana KUČEROVÁ, Radka MARČEKOVÁ, Gabriela NEDELOVÁ

Abstract

The wellness tourism market in four selected tourist regions in Slovakia is analysed in this paper. The results of field research, conducted by means of a questionnaire survey carried out by the ATLAS research group, are presented. A primary objective is to investigate the inter-dependencies between life style and participation in wellness tourism. Associations between existing demand for wellness facilities and six independent variables (smoking, fitness activities in daily life, diet, age, educational level and nationality) are tested. The differences among particular results of the field research in the four regions are discussed, as well as the overall results for the four regions as a whole. The field research data are evaluated by means of statistical software packages (SPSS/PASW), using non-parametric tests (Fischer Exact Test and Cramer's V statistics). The inter-dependencies among the six independent variables and visiting wellness facilities are exemplified in this project.

Shrnutí

Wellness cestovní ruch na Slovensku

Cílem příspěvku je analýza trhu cestovního ruchu wellness ve čtyřech regionech cestovního ruchu na Slovensku a prezentace výsledků primárního výzkumu, který se uskutečnil na základě dotazníkového průzkumu, připraveného skupinou odborníků v rámci světové asociace výzkumu v cestovním ruchu (ATLAS). Příspěvek prezentuje závislost mezi životním stylem účastníků cestovního ruchu a návštěvností zařízení wellness cestovního uchu na Slovensku. Testujeme závislost mezi existující poptávkou po wellness zařízeních a kouřením, vykonáváním aktivit fitness, dietním stravováním v běžném životě, věku, vzdělanostní úrovní a národností účastníků. Prezentujeme rozdíly ve výsledcích primárního výzkumu ve čtyřech zkoumaných regionech cestovního ruchu a následně sumarizujeme výsledky za Slovensko. Výsledky primárního výzkumu hodnotíme pomocí statistického programu SPSS, verze 13.0 a programu PASW, verze 17.0. Pomocí Fischerova testu a Cramerova testu verifikujeme závislost mezi 6 proměnnými faktory a návštěvností zařízení wellness cestovního ruchu na Slovensku.

Key words: *wellness tourism, Orava tourist region, Tatra tourist region, Váh valley region, Liptov tourist region, lifestyle, Slovakia*

1. Introduction

Wellness tourism is a relatively new trend in tourism development worldwide. Therefore, also the countries in central and eastern part of Europe are trying to create wellness tourism products. The Slovak Republic is situated in the central part of Europe. It came into existence in 1993 as an independent state, which had been from 1918 the part of previous Czechoslovakia. Slovakia became an EU member state in 2004 and a member of Euro zone in January 2009.

In the territory of the Slovak Republic, there are many mineral springs and huge supplies of ground water. While the whole of Slovakia is studded with mineral springs, the biggest supplies of ground water are in the Danube River basin, and namely on the Golden Wheat Island (Žitný ostrov) with an approximate amount of 10 billion m^3 water. Slovakia is extremely rich in mineral and hot spring waters, out of which many have healing effects. More than 1,700 springs of mineral and hot waters are located in Slovakia and there is hardly an area, where they would not occur (http://www.slovakia.travel.com). Many of the mineral springs are thermal springs (with a temperature above 20 °C). Near the mineral and thermal springs, many healing and recreational spas have been built. Thermal springs are also utilized by many aqua parks that have become very popular.

In many facilities in Slovakia, which had been built during the previous regime and utilized the curative effects of climate, mineral and hot springs waters, the wellness trend started to develop in the 1990s and mainly at the beginning of 21st century. In the past, the greatest emphasis was paid to curative effects of

these natural resources in the treatment of patients. These had to follow strict recommendations of doctors for treatment. Almost 95% of visitors in these facilities were prescribed treatment by doctors and their stay was fully or partially covered by the national health insurance system. The obligatory length of stay was min. three weeks, as many doctors are still convinced that three weeks of the treatment are necessary for patients to be able to absorb all curative effects of these natural resources and related treatment.

Nowadays more and more facilities provide their services as inevitable part of the new lifestyle and stress the need of prevention again illness, which is the responsibility of every individual. The participation in wellness tourism is still growing motivation for visitors. More and more visitors consider wellness as part of their lifestyle, with the objective to achieve the harmony of their mental, emotional and physical health or as an inevitable part of their life philosophy. More authors (Travis, www.seekwellness.com; Müller and Lanz Kaufmann, www.lanzkaufmann.ch; Myers, Sweeney, Witmer, www.trrworld.org; Hertel, www.wellnessverband.de; Horx in Wiesner (2007); Javorská (2006) stress the fact, that wellness tourism is closely interconnected with the healthy lifestyle of visitors.

Horx, Horx-Strathern and Gaspar (in Berg, 2008) define 5 megatrends with a positive influence on wellness tourism development in the future. They are the attempt of population to live longer, the active influence on the individual's health, wellness as a mean of stress and working burden elimination, wellness as a mean to achieve internal balance in the society full of individualists, the increasing interest in wellness activities mainly in female population. Nahrstedt (2008) points out the increasing interest in wellness services also in men's population and stresses the fact, that there are limited differences in the interest in leisure activities including wellness activities between males and females and this trend will be remarkable namely in the future.

Burák (2007) stresses, that lifestyle affects the health of humans at more than 50%. The rest is influenced by genetic factors, environment and by the level of health care system in the country. The lifestyle is influenced by positive as well as by negative factors. The negative factors, risky factors are mainly smoking, unhealthy nutrition, lack of physical activities, alcohol, high blood pressure, disturbances in metabolic system and excess weight. Positive factors are according to this author healthy food, fresh and clean air, physical activities, rest, good mental condition and avoiding of toxic materials.

The term of healthy lifestyle is closely connected with the term health. Health is in human society considered as absence of illness. In case that an individual has no signs of illness, he/she is considered healthy. A broader characteristic of health is provided in the definition of WHO from 1947 (Smith, Puczkó, 2008). According to this definition, health is the state of full physical, mental and social well-being. According to Blahušová (1995), the lifestyle wellness has five major components (positive attitude to life, personal habits, nutrition and weight control, coping with stress and fitness). Each of these factors affects the subjective feeling of well-being; all these factors are in interaction and influence each other. Horníková (2005) defines the lifestyle wellness as co-operation of human body, brain and spirit with the objective to recognize, that everything what we are doing, how and what we are thinking and feeling and what we believe in has influence on our health.

2. The objective, material and research methodology

The objective of this paper is to find out a dependency between the visiting of wellness facilities and the visitors' lifestyle in Slovakia. We verify the hypothesis that there is a dependency between participation in wellness tourism and the visitors' lifestyle. The hypothesis is verified by Fisher Exact test at a level of significance 0.1. This test helps us to verify dependency of investigated factors. There is a dependency between the investigated variables in case that the value of Sig is close to zero. The rate of interdependence intensity of particular factors will be described by means of Cramer's V statistics.

The research samples are visitors of selected wellness facilities in four Slovak tourist regions (Fig. 1). Three of them (Tatra, Liptov and the northern part of the Váh River basin region) are according to valid Regionalization of Tourism in Slovakia of international importance and one of them (Orava region) is of national importance in tourism development.

The primary research was conducted by using a questionnaire, which was elaborated by the ATLAS (World Association of Tourism and Leisure Studies) research group with the objective to conduct the market survey in more European countries. We have translated this questionnaire into six foreign languages (English, German, Hungarian, Polish, Slovak and Russian), as visitors from neighbouring countries are already a long time typical target groups in international arrivals in Slovakia. The questionnaires were distributed directly at the front desk of wellness centres, so that we could get answers from visitors of these facilities.

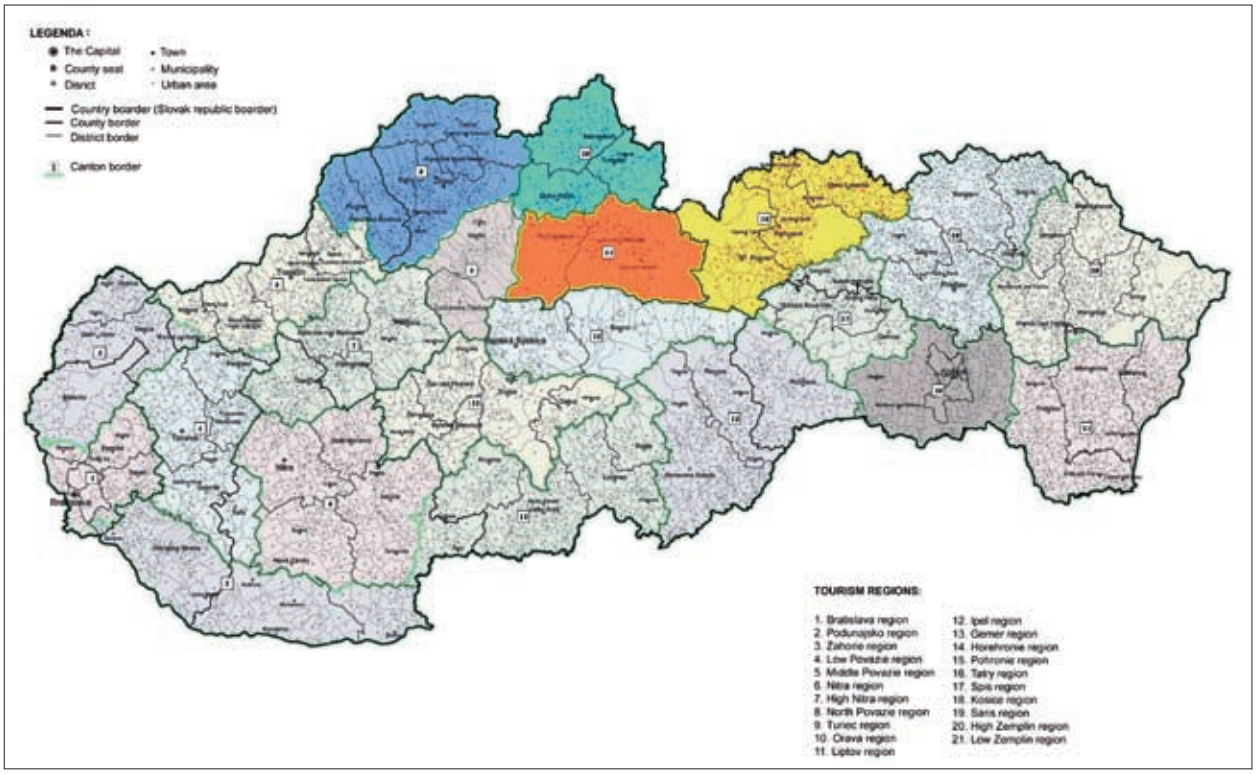

Fig. 1: Tourism regions in Slovakia (The Váh R. Valley region is labeled as North Považie region in the map)
Source: Torism regionalisation in Slovak Republic (online) Availabe at http://www.economy.gov.sk

The field research has been realized in the period from December 2008 till March 2009. The questionnaires were distributed in 21 wellness facilities (16 wellness hotels, 3 Aqua parks, 2 curative spa resorts). Nine of the facilities are located in the Tatra tourist region, four are situated in the Liptov tourist region, five facilities are located in the Váh R. valley region and three in the Orava tourist region. Altogether 1,315 questionnaires were distributed and 623 of them were answered, i.e. the return rate was 47.4%.

The questionnaires were distributed within the co-operation of facilities and with a kind help of the employees from the wellness centres and their receptionists.

The questionnaires were evaluated by using the statistical software SPSS, version 13.0 and the statistical software PASW, version 17.0. By means of Fischer Exact Test we verified dependence between six variables and the attendance of wellness facilities. Three of the six variables create characteristics of visitors' lifestyle (smoking, regular fitness activities and healthy nutrition – the term diet was explained to respondents in the questionnaire by examples such as purchase of food with limited fat and without added sugar) and other three variables were socio-economic characteristics of respondents (age, level of education and nationality).

Tourist region	%
Tatra tourist region	19.4
Liptov tourist region	31.0
Váh River valley region	33.7
Orava tourist region	15.9

Tab. 1: The share of Respondents in Tourist Regions
Source: Processed by the authors

3. Research findings

There were differences in results from the field research in the studied tourist regions. Therefore, we will present the results of our field research in particular tourist regions. At the end of this paper, we will provide a synthesis of the field research for the whole Slovakia.

3.1 The High Tatra tourist region

The market survey was made in 8 hotels with wellness and in one Aqua park – Aqua City Poprad, which had been granted the World Travel Award in 2007 and the Award "World's Leading Green Resort" in 2008.

Two of eight hotels meet the criteria of the new legislation in Slovakia (Act No. 277/2008 of the Ministry of Economy of SR) about the standardization of accommodation facilities. This new law identifies the quality standards

also for wellness hotels. These standards are formulated more like technical standards and do not comprise so called "soft quality" requirements for wellness facilities. Three hundred questionnaires were distributed in these facilities and we achieved a return rate of 40%, i.e. we had 121 questionnaires available for our research. The results of the field research proved, that 75.2% of all respondents perform fitness activities in their everyday life (but at a different intensity). Almost 25% of respondents do not pay attention to fitness activities in their everyday life.

Slovak nationals represented 90.1% of all respondents in this region, 6.6% were Germans, 2.5% English and one respondent was from Russia. The fact was affected also by the period of the market survey. The economic crisis as well as the declining foreign currency rate in neighbouring countries and the acceptance of euro in Slovakia in January 2009 had a negative impact on international arrivals in Slovakia.

As to the characteristics of visitors' lifestyle, 63.6% of respondents were non-smokers, 36.4% considered themselves smokers. 56.2% of respondents are on no diet and do not pay attention to special healthy nutrition. The other 43.8% respondents pay attention to healthy nutrition in their everyday life.

The socio-economic characteristics of respondents were as follows: 34.7% were visitors aged from 19 to 29 years, 35.6% belonged to the age group 30–39 years, 19.8% were visitors from 40 to 49 years old, 8.3% of respondents were in the age group from 50 to 59 and the rest (1.6%) were visitors from 60 to 69 years.

Only one respondent had the basic education, 46.3% of respondents achieved a secondary school (high school) education and more than a half of respondents (52.9%) had higher education including university.

Name of the facility	Location
Grandhotel****	Starý Smokovec
Grand hotel Bellevue****	Starý Smokovec
Hotel Hills****	Stará Lesná
Hotel International****	Veľká Lomnica
Hotel Átrium****	Nový Smokovec
Wellness hotel Kontakt****	Stará Lesná
Clubhotel Nezábudka***	Tatranská Štrba
Hotel Toliar***	Štrbské Pleso
Aquapark AquaCity	Poprad

Tab. 2: Facilities in the Tatra tourist region
Source: Authors

Based on the market survey we can state, that in the Tatra tourist region, most visitors of wellness facilities are Slovaks with higher education aged up to 39 years, who do not smoke, do fitness in their everyday life and do not pay any special attention to diet and healthy food.

3.2 The Liptov tourist region

The market survey in the Liptov tourist region was conducted in two hotels with wellness centres, one aqua park and in one curative spa resort. None of the hotels was classified as wellness hotel according to the Act No. 277/2008 of the Ministry of Economy of SR. In spite of the fact, that both hotels meet the criteria, i.e. they are entitled to use the name wellness hotel, they have not changed their commercial name up to now. We distributed 415 questionnaires in these facilities and 193 were returned, which means that the return rate was 46.5%.

Name of the facility	Location
Grand hotel Permon****	Podbanské
Hotel Grand****	Jasná
Aquapark Tatralandia	Liptovský Mikuláš
Liptovské liečebné kúpele a. s.	Lúčky

Tab. 3: Facilities in the Liptov tourist region
Source: Authors

About 70% of visitors do fitness activities in everyday life at various intensity and 29.3% of respondents do not care about fitness in their everyday life. Almost 80% of respondents were non-smokers, the rest (20.2%) considered themselves as smokers. 50.3% of respondents have no diet and 49.7%have in everyday life sort of a diet and pay attention to healthy nutrition.

Most respondents were people up to 29 years (34.4%); 23.8% were respondents aged from 30 to 39 years, 18.9% were middle-aged (40–49 years) and older respondents from 50 to 59 years formed 14.8%. 2.5% of respondents were visitors aged from 60 to 69 and 5.6% of visitors were over 70 years. This older generation showed a higher attendance in the Liptovské liečebné kúpele, a.s. – a traditional spa resort with curative natural resources.

Approximately 2.5% of respondents had a basic education, 44% were secondary school leavers and 53.6% of respondents had a higher education including university.

Most respondents were Slovak nationals (68.4%), Polish respondents presented 13.5%, Czechs 10.3% and visitors from USA, Germany, Hungary and Russia represented 7.8% of the research sample.

Based on the market survey we can stress, that a majority of visitors to wellness facilities in the Liptov tourist region are Slovaks with a higher education, who do not smoke, pay attention to fitness activities in their everyday life and do not pay attention to diet and healthy food. The visitors are in all age groups.

3.3 The Northern part of the Váh R. Valley region

The market survey in this region was carried out in five facilities with wellness services. Just one of these hotels has made use of the possibility given by the Act No. 277/2008 of the Ministry of Economy, SR and uses the title of wellness hotel. We distributed 400 questionnaires in these facilities and obtained 210 back, i.e. the return rate was 52.5%.

Name of the facility	Location
Šport Wellness Hotel Diplomat****	Rajecké Teplice
Hotel Bránica****	Terchová
Hotel Wili****	Púchov
Hotel Aphrodite****	Rajecké Teplice
Kúpele Nimnica a. s.	Nimnica

Tab. 4: Facilities in the Northern part of the Váh R. Valley region
Source: Authors

Most respondents (78.1%) were visitors of younger and middle age from 19 to 29 years (24.3%), 31% were from 30 to 39 years and 22.8% were visitors from the age group of 40–49 years, 14.3% of respondents were aged from 50 to 59, 4.8% were from 60 to 69 years old and just 2.8% of respondents were above 70 years of age. More than 58% of respondents do not pay attention to any diet or healthy nutrition in their everyday life and the other 41.9% pay attention to diet and healthy food.

None of the respondents had just basic education, 51% of respondents had a secondary school education and 49% had a higher education. About 67% of respondents were non-smokers, 32.9% were smokers. Less than a half of the respondents (47.6%) pay attention to fitness activities in their everyday life at various intensity and 52.4% do not make fitness. 74.8% of all respondents were Slovak nationals, 25.2% were visitors from Poland, Czech Republic, Germany, Austria, Croatia and Hungary.

Based on the results of our field research we can state, that a greater part of visitors in wellness facilities in the Northern part of the Váh River valley region are Slovaks with a secondary school education aged from 19 to 49 years, who do not smoke and do not pay attention to fitness activities and diet and healthy nutrition in their everyday life.

3.4 The Orava tourist region

The market survey in the Orava tourist region was carried out in three facilities with wellness services (all existing ones). We distributed 200 questionnaires in these facilities and received 99 of them back, i.e. the return rate was 49.5%.

Name of the facility	Location
Garden Hotel & Resort Oravský Háj***	Brezovica
Aquapark Meander Park Thermal	Oravice
Tyrapol wellness hotel **	Oravská Lesná

Tab. 5: Facilities in the Orava Tourist Region
Source: Authors

Smokers represented 64.6% of respondents and non-smokers amounted to 35.4%. Visitors who are doing fitness activities in their everyday life at various intensity represented 67.7%, the rest (32.3%) do not care about fitness in their everyday life. On the other hand, a majority of respondents (57.6%) pay attention to diet and healthy food in their everyday life.

Almost third of respondents (31.3%) were aged from 19 to 29 years, 23.2% were visitors from two age groups (30 to 39 years and from 40 to 49 years), 15.2% were visitors aged from 50 to 59 years and 5% were visitors aged from 60 to 69 years. We can state, that 77.7% of all respondents were people from younger and middle age groups.

More than a half of respondents (51.5%) had a higher education, secondary school education was represented by 47.5% of respondents and one had a basic education.

Most respondents (46.5%) were Polish, Slovaks represented 32.3% of respondents, 11.1% were Hungarian visitors and 10.1% were respondents from other countries mainly from the Czech Republic, Austria, Germany and Spain.

Based on the market survey we can estimate, that most visitors in the wellness facilities in the Orava region are Polish nationals (due to location of this region near the Polish borders), they have a higher and secondary school education, they are smokers and in every day life pay greater attention to fitness activities and various diet and healthy nutrition. Table 6 shows regional differences in the market survey.

3.5 Slovak Republic

As it was not possible to prove statistically the dependence between the lifestyle of visitors and the attendance of wellness facilities due to the insufficient number of respondents in the individual regions, we analyzed all 623 questionnaires on a basis of the same

Tourist Region	Variable expressed in %					
	fitness YES	diet YES	prevailing nationality	smoking YES	prevailing education level	prevailing age group (years / %)
High Tatra	75.2	43.8	Slovak 90.0	36.4	HE 52.9	19–39 / 70.3
Liptov	70.7	49.7	Slovak 68.4	20.2	HE 53.6	19–39 / 58.2
Váh R. Valley	47.6	41.9	Slovak 74.8	32.9	SE 51.0	19–39 / 55.3
Orava	67.7	57.6	Polish 46.5	64.6	HE 51.5	19–39 / 54.5

Tab. 6: Regional differences (HE – higher education; SE – secondary school education)
Source: Authors

research method as was used to analyze the regions. The statistical testing makes it possible to evaluate the primary research and the collected respondents' answers also in the case, that the respondent does not answer all questions. Therefore, we have no equal summary numbers of responses in Tables 7, 10, 13, 15, 18, 21.

The analysis of field research results confirmed the dependence between smoking and visiting wellness facilities. Cramer's V statistics at a level of significance 0.1 confirmed weak and medium dependence. 65.3% of respondents were non-smokers. The results are presented in Tab. 7.

The field research confirmed also the existence of dependence between the fitness activities of visitors and the visiting of wellness facilities. Cramer's V statistics confirmed at a significance level 0.1 a weak and medium dependence rate between these two variables. 63.3% of respondents are people, who are doing fitness activities in their everyday life at various intensities. 36.7% of respondents do not pay attention to fitness (Tab. 10).

The survey did not confirm the dependence between diet and healthy nutrition and visiting wellness facilities. The respondents in all four regions who pay attention to diet and healthy food in their everyday life represented 47.2% and those who do not pay attention to this fact created 52.8% from all respondents. This fact can be an explanation of the statement, that there is no dependence between the diet of the visitors and their participation in wellness tourism (Tab. 13).

The statistical evaluation confirmed the dependence between the visiting of wellness facilities and the age of visitors. Cramer's V statistics at a significance level

	Frequency of visits per year						Total
	never	no more than once	occasionally	regularly	every week	more than once a week	
Non-smokers	2	17	199	123	47	19	407
Smokers	7	17	130	46	11	5	216
Total	9	34	329	169	58	24	623

Tab. 7: Visiting wellness facilities and smoking
Source: Statistical evaluation in the PASW system, version 17.0, 2009

	Value	df	Asymp. Sig. (2-sided)	Monte Carlo Sig. (2-sided)		
				sig.	99% Confidence Interval	
					lower bound	upper bound
Pearson Chi-square	26.806[a]	5	.000	.000[b]	.000	.000
Likelihood ratio	27.190	5	.000	.000[b]	.000	.000
Fisher's Exact test	26.391			**.000[b]**	.000	.000
Linear-by-Linear Association	23.681[c]	1	.000	.000[b]	.000	.000
N of valid cases	623					

Tab. 8: Dependence between the visiting of wellness facilities in SR and smoking (Fischer's Exact Test)
Source: Statistical evaluation in the PASW system, version 17.0, 2009
Interpretation: Variables are dependent

		Value	Approx. Sig.	Monte Carlo Sig. (2-sided)		
				sig.	99% Confidence Interval	
					lower bound	upper bound
Nominal by Nominal	Phi	.207	.000	.000[a]	.000	.000
	Cramer's V	.207	.000	.000[a]	.000	.000
N of valid cases		623				

Tab. 9: Dependence between the visiting of wellness facilities in SR and smoking (Cramer's V statistics)
Source: Statistical evaluation
Interpretation: At a significance level 0.1, we confirm that weak and middle dependence exists between the visiting of wellness facilities and smoking in the PASW system, version 17.0, 2009

	Frequency of visits per year						Total
	never	no more than once	occasionally	regularly	every week	more than once a week	
Fitness activities NO	3	14	137	52	13	8	227
Fitness activities YES	6	20	189	116	45	16	392
Total	9	34	326	168	58	24	619

Tab. 10: Visiting wellness facilities and fitness activities in everyday life
Source: Statistical evaluation in the PASW system, version 17.0, 2009

	Value	df	Asymp. Sig. (2-sided)	Monte Carlo Sig. (2-sided)		
				sig.	99% Confidence Interval	
					lower bound	upper bound
Pearson Chi-square	11.921[a]	5	.036	.032[b]	.027	.036
Likelihood ratio	12.304	5	.031	.034[b]	.029	.038
Fisher's Exact test	12.055			.030[b]	.025	.034
Linear-by-Linear Association	6.963[c]	1	.008	.010[b]	.007	.012
N of valid cases	619					

Tab. 11: Dependence between the visiting of wellness facilities in SR and fitness activities in everyday life (Fischer's Exact Test)
Source: Statistical evaluation in the PASW system, version 17.0, 2009
Interpretation: Variables are dependent

		Value	Approx. Sig.	Monte Carlo Sig. (2-sided)		
				sig.	99% Confidence Interval	
					lower bound	upper bound
Nominal by Nominal	Phi	.139	.036	.032[a]	.027	.036
	Cramer's V	.139	.036	.032[a]	.027	.036
N of valid cases		619				

Tab. 12: Dependence between the visiting of wellness facilities in SR and fitness activities in everyday life (Cramer's V statistics)
Source: Statistical evaluation in the PASW system, version 17.0, 2009
Interpretation: At a significance level 0.1 we confirm that weak and middle dependence exist between visiting wellness facilities and fitness activities in everyday life in SR

0.1 proved weak and medium dependence rate. The majority of respondents in four regions are people aged from 19 to 29 years (30.1%), respondents aged from 30 to 39 years represented 29% and respondents aged from 40 to 49 years formed 21.4%. The older generation aged from 50 to 59 years represented 13.2%, at the age from 60 to 69 years 3.6% and 2.5% were over 70 years (Tab. 15).

The statistical evaluation has confirmed also the dependence between the visiting of wellness facilities and the education of visitors. Cramer's V statistics confirmed at a significance level 0.1 weak and medium dependence rate between these two variables. 51.4% of respondents had higher education, 47.8% secondary school education and just 0.8% of respondents had basic education. The results are shown in Tab. 18.

The dependence between the visiting of wellness facilities and the nationality of visitors was confirmed as well. Cramer's V statistics at a significance level 0.1 confirmed weak and medium dependence between these two variables. The majority of respondents were Slovaks (69%), than Polish (14.1%), Czechs (6.6%), Germans (5%), Hungarians (2.7%) and Austrians (1%). See the results in Tab. 21.

Based on the summarized results of the market survey for all four Slovak tourist regions we can confirm dependence between the lifestyle of visitors and the visiting of wellness facilities. From a total of six analyzed variables, the dependence was confirmed in five (smoking, fitness activities in everyday life, age, nationality and education).

The only one exception is diet and healthy nutrition, which is not interdependent with the visiting of wellness facilities. The majority of visitors to wellness facilities in the four studied Slovak regions are Slovak nationals aged from 19 to 39 years with a higher education, non-smokers, paying attention to fitness activities in their everyday life, but not caring about diet and healthy nutrition.

4. Conclusion

The wellness trend has influenced also the supply of wellness services in many facilities in Slovakia. This country has long-term tradition in the utilization of hot and mineral springs as well as climate for the treatment of people under strict medical control. In the last 15 years, mainly after the privatization of traditional spas, the orientation on wellness services for visitors in tourism has become very popular. These facilities are nowadays visited not only for the curative effects of natural resources, but also for prevention again illnesses. In spite of the fact, that more authors (Travis, http://www.seekwellness.com; Müller and Lanz Kaufmann, http://www.lanzkaufmann.ch; Myers, Sweeney, Witmer, http://www.trrworld.org; Hertel, http://www.wellnessverband.de; Horx in Wiesner (2007); Javorská (2006) point out the fact, that the

	Frequency of visits per year						Total
	never	no more than once	occasionally	regularly	every week	more than once a week	
Diet NO	6	18	175	90	28	12	329
Diet YES	3	16	154	79	30	12	294
Total	9	34	329	169	58	24	623

Tab. 13: Visiting of wellness facilities and diet, healthy nutrition
Source: Statistical evaluation in PASW, version 17.0, 2009

	Value	df	Asymp. Sig. (2-sided)	Monte Carlo Sig. (2-sided)		
				sig.	99% Confidence Interval	
					lower bound	upper bound
Pearson Chi-square	1.281[a]	5	.937	.939[b]	.933	.945
Likelihood ratio	1.297	5	.935	.938[b]	.932	.944
Fisher's Exact test	1.297			.943[b]	.937	.949
Linear-by-Linear Association	.613[c]	1	.434	.439[b]	.426	.451
N of valid cases	623					

Tab. 14: Dependence between the visiting of wellness facilities in SR and the diet (Fischer's Exact Test)
Source: Statistical evaluation in the PASW system, version 17.0
Interpretation: Variables are dependent

Age	Frequency of visits per year						Total
	never	no more than once	occasionally	regularly	every week	more than once a week	
0–18	0	0	0	1	0	0	1
19–29	1	9	91	37	18	10	166
30–39	2	6	98	45	7	2	160
40–49	0	9	64	31	9	5	118
50–59	5	4	33	20	11	0	73
60–69	0	2	11	5	1	1	20
above 70	1	1	8	4	0	0	14
Total	9	31	305	143	46	18	552

Tab. 15: Visiting of wellness facilities and the age of visitors
Source: Statistical evaluation in the PASW system, version 17.0, 2009

	Value	df	Asymp. Sig. (2-sided)	Monte Carlo Sig. (2-sided)		
				sig.	99% Confidence Interval	
					lower bound	upper bound
Pearson Chi-square	46.378[a]	30	.029	.079[b]	.072	.085
Likelihood ratio	45.740	30	.033	.018[b]	.014	.021
Fisher's Exact test	46.069			.019[b]	.016	.023
Linear-by-Linear Association	3.008[c]	1	.083	.082[b]	.074	.089
N of valid cases	552					

Tab. 16: Dependence between the visiting of wellness facilities in SR and the age of visitors (Fischer's Exact Test)
Source: Statistical evaluation in the PASW system, version 17.0, 2009
Interpretation: Variables are dependent

		Value	Approx. Sig.	Monte Carlo Sig. (2-sided)		
				sig.	99% Confidence Interval	
					lower bound	upper bound
Nominal by Nominal	Phi	.290	.029	.079[a]	.072	.085
	Cramer's V	.130	.029	.079[a]	.072	.085
N of valid cases		552				

Tab. 17: Dependence between the visiting of wellness facilities in SR and the age of visitors (Cramer's V statistics)
Source: Statistical evaluation in the PASW system, version 17.0, 2009
Interpretation: At a significance level 0.1 we confirm weak and middle dependence between the visiting of wellness facilities and the age of visitors in SR

	Frequency of visits per year						Total
	never	no more than once	occasionally	regularly	every week	more than once a week	
Basic	0	1	2	2	0	0	5
Secondary	7	13	161	57	16	11	265
Higher	2	17	143	86	30	7	285
Total	9	31	306	145	46	18	555

Tab. 18: Visiting of wellness facilities and visitors' education
Source: Statistical evaluation in the PASW system, version 17.0, 2009

wellness tourism is closely interconnected with the healthy lifestyle of visitors, the field research results in Slovakia do not fully prove the statement.

The market survey conducted in four Slovak tourist regions showed that the dependence between the lifestyle of visitors and the visiting of wellness facilities varies in these four destinations. This statement could not be proved statistically. The reason may be an insufficient number of respondents from the statistical point of view or a statistically equable distribution of less frequent answers, which makes it impossible to prove dependence between the variables in the individual tourist regions. This is why we analyzed data for all respondents in the four tourist regions. Thanks to a relatively high number of respondents (623) and by means of statistical evaluation in the system PASW, version 17.0 (2009), we demonstrated interdependence between the visiting of wellness facilities and five variables. The only one dependence that failed to be proved is dependence between the visiting of wellness facilities and the healthy nutrition or diet of visitors. On the other hand, based on the results of the market survey in the individual regions, we can estimate that attendance in the wellness tourism in Slovakia is not significantly influenced by the lifestyle of visitors, but that the wellness tourism facilities are rather considered by visitors as tourist attractions like any other attractions. The wellness facilities should pay a greater attention to consulting services, mainly in the field of healthy nutrition and they could contribute in this way also to a positive change in the lifestyle of visitors. Unfortunately, the consultancy services in the field of lifestyle for visitors are not obligatory standards mentioned in the Act No. 277/2008 of the Ministry of Economy of the Slovak Republic about the standardization of accommodation facilities including wellness hotels. The law itself does not pay attention to training of employees in the field of lifestyle and does not comprise so called "soft" quality standards such as environs, behaviour of employees, architecture, healthy nutrition etc. There are no national quality standards for Aqua parks in Slovakia. On the other hand, one of the facilities, where the market survey was conducted – Aqua City Poprad – has achieved the World Tourism Award for the high quality of services and for the implementation of environmental technologies in the utilization of thermal springs and energy.

The wellness facilities in Slovakia should play a more proactive role in the creation of healthy lifestyle of their visitors. Consultancy services including great supply of healthy food could be attractive for visitors as a part of their own self-improvement.

	Value	**df**	**Asymp. Sig. (2-sided)**	**Monte Carlo Sig. (2-sided)**		
				sig.	99% Confidence Interval	
					lower bound	upper bound
Pearson Chi-square	17.873[a]	10	.057	.088[b]	.081	.095
Likelihood ratio	17.963	10	.056	.033[b]	.029	.038
Fisher's Exact test	18.918			.028[b]	.024	.033
Linear-by-Linear Association	4.320[c]	1	.038	.041[b]	.036	.046
N of valid cases	555					

Tab. 19: Dependence between the visiting of wellness facilities in SR and the educational level of visitors (Fischer's Exact Test)
Source: Statistical evaluation in the PASW system, version 17.0, 2009
Interpretation: Variables are dependent

		Value	**Approx. Sig.**	**Monte Carlo Sig. (2-sided)**		
				sig.	99% Confidence Interval	
					lower bound	upper bound
Nominal by Nominal	Phi	.179	.057	.088[a]	.081	.095
	Cramer's V	.127	.057	.088[a]	.081	.095
N of valid cases		555				

Tab. 20: Dependence between the visiting of wellness facilities in SR and the educational level of visitors (Cramer's V statistics)
Source: Statistical evaluation in the PASW system, version 17.0, 2009
Interpretation: At a significance level 0.1 we confirm weak and middle dependence between the visiting of wellness facilities in SR and the educational level of visitors

Age	Frequency of visits per year						Total
	never	no more than once	occasionally	regularly	every week	more than once a week	
USA	0	0	1	0	0	0	1
Austria	0	0	6	0	0	0	6
Croatia	0	0	0	2	0	0	2
Czech Republic	1	2	16	15	5	2	41
UK	0	1	2	0	0	0	3
Germany	0	2	7	16	6	0	31
Hungary	0	0	14	2	1	0	17
Poland	1	4	53	20	7	3	88
Russia	0	0	2	0	0	1	3
Slovak Republic	7	25	227	114	39	18	430
Spain	0	0	1	0	0	0	1
Total	9	34	329	169	58	24	623

Tab. 21: Visiting of wellness facilities and nationality of visitors
Source: Statistical evaluation in the PASW system, version 17.0, 2009

	Value	df	Asymp. Sig. (2-sided)	Monte Carlo Sig. (2-sided)		
				sig.	99% Confidence Interval	
					lower bound	upper bound
Pearson Chi-square	73.249[a]	55	.051	.140[b]	.131	.149
Likelihood ratio	75.539	55	.034	.002[b]	.001	.003
Fisher's Exact test	82.680			.006[b]	.004	.008
N of valid cases	623					

Tab. 22: Dependence between the visiting of wellness facilities in SR and the nationality of visitors (Fischer's Exact test)
Source: Statistical evaluation in the PASW system, version 17.0, 2009
Interpretation: Variables are dependent

		Value	Approx. Sig.	Monte Carlo Sig. (2-sided)		
				sig.	99% Confidence Interval	
					lower bound	upper bound
Nominal by Nominal	Phi	.343	.051	.140[a]	.131	.149
	Cramer's V	.153	.051	.140[a]	.131	.149
N of valid cases		623				

Tab. 23: Dependence between the visiting of wellness facilities and the nationality of visitors (Cramer's V statistics)
Source: Statistical evaluation in the PASW system, version 17.0, 2009
Interpretation: At a significance level 0.1 we confirm weak and middle dependence between the visiting of wellness facilities in SR and the nationality of visitors

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www.slovakia.travel.com

Authors' addresses:

Assoc. Prof. Ing. Jana KUČEROVÁ, Ph.D., e-mail: *jana.kucerova@umb.sk*
Ing. Radka MARČEKOVÁ, e-mail: *radka.faksova@umb.sk*
RNDr. Gabriela NEDELOVÁ, Ph.D., e-mail: *gabriela.nedelova@umb.sk*
Faculty of Economics, Matej Bel University,
Tajovského 10, 975 90 Banská Bystrica, Slovakia

RELICT CRYOPLANATION AND NIVATION LANDFORMS IN THE CZECH REPUBLIC: A CASE STUDY OF THE SÝKOŘSKÁ HORNATINA MTS.

Jaromír DEMEK, Marek HAVLÍČEK, Peter MACKOVČIN

Abstract

Relict cryogenic landforms of Pleistocene age were studied in this project, with a case study of the Sýkořská hornatina Mts. in the central part of the Czech Republic. The bedrock in the area is composed mainly from orthogneiss of the Moravian-Silesian terrane of Proterozoic age. Bedrock outcrops on mountain tops and ridges exhibit interesting cryogenic forms, modelled by frost weathering and other cryogenic processes during the long cold phases of the Pleistocene Epoch. The most valuable cryoplanation and nivation landforms are protected by the Government under Act No. 114/1992 Gazette on Nature and Landscape Protection.

Shrnutí

Reliktní kryoplanační a nivační formy reliéfu v České republice: případová studie Sýkořská hornatina

Autoři studovali pleistocenní kryogenní tvary vyskytující se v Sýkořské hornatině severně od Brna. Kryogenní tvary se nacházejí na vrcholech a hřbetech hornatiny tvořené proterozoickými rulami bítešské skupiny moravsko-slezského teránu. Kryogenní pochody v chladných obdobích pleistocénu vymodelovaly v podmínkách dlouhodobě zmrzlé půdy v hornatině pestrý soubor tvarů georeliéfu. Významné kryogenní tvary jsou chráněné zákonem č. 114/92 Sb. o ochraně přírody a krajiny ve znění pozdějších změn.

Key words: *Pleistocene cryoplanation and nivation, cryoplanation terraces, tors, nature protection, strictly protected areas, Sýkořská hornatina Mts., Czech Republic*

1. Introduction

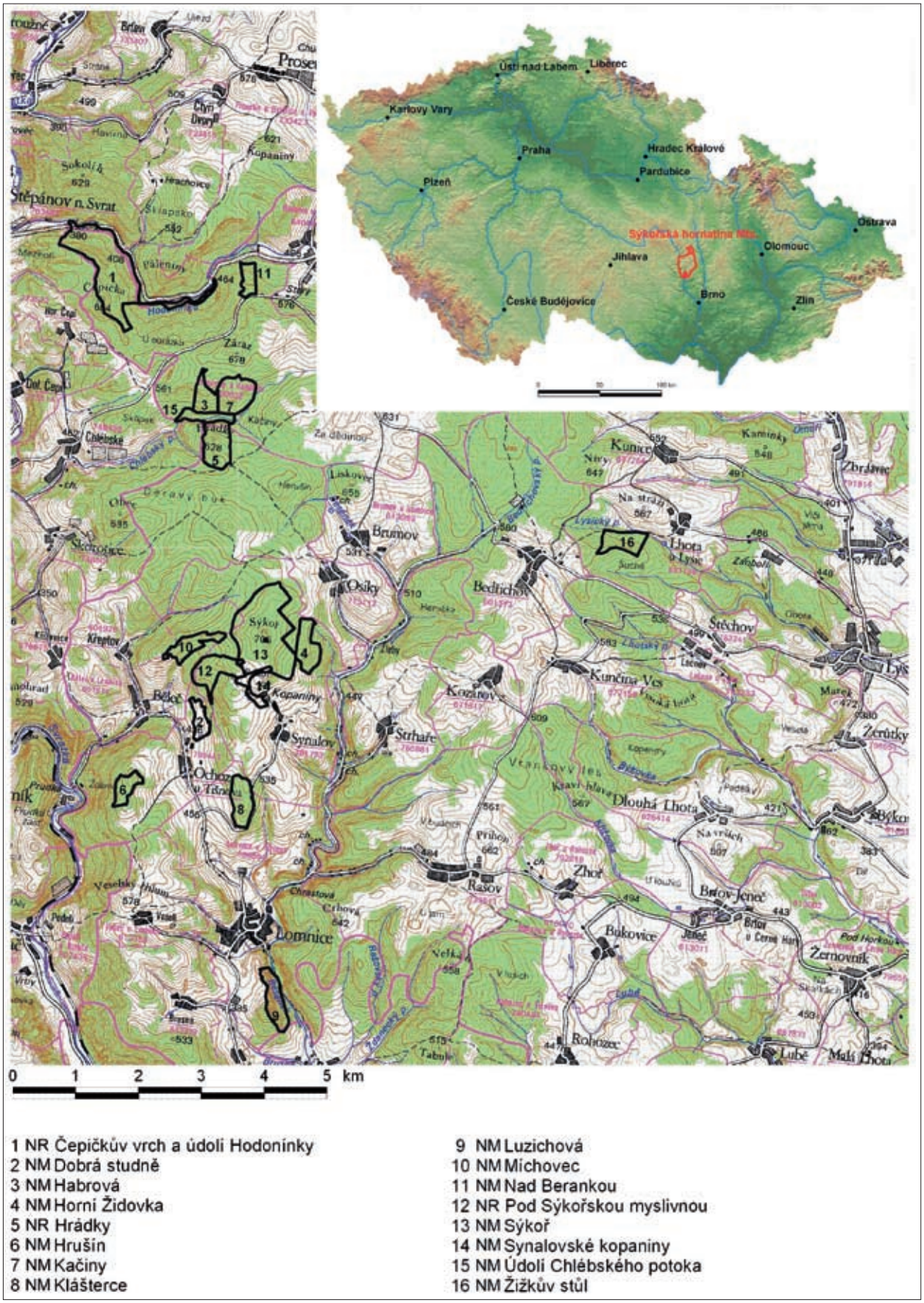
Cryogenic landforms are features resulting from the action of intense frost, often combined with the presence of permafrost. Important geomorphological processes in the landscapes of cold environments are cryoplanation and nivation. Especially rocky landforms created by these processes (cryoplanation terraces, tors, castle koppies, nivation hollows) are not only important geomorphological features but also interesting and beautiful elements of landscapes. Therefore, the most valuable cryoplanation and nivation landforms are on the territory of the Czech Republic protected by the Government under the Act No. 114/1992 Gazette on Nature and Landscape Protection. For Specially Protected Areas in the study area see Tab. 1.

The authors studied relict cryoplanation and nivation landforms in the Sýkořská hornatina Mts. in the central part of the Czech Republic famous for many nice cryogenic landforms of Pleistocene age (Hrádek, 1980, 1999; Lacina, Hrádek, 2001; Demek, Mackovčin [eds.] et al., 2006).

2. Study area

The Sýkořská hornatina Mts. are situated in the eastern part of the Českomoravská vrchovina (Bohemian-Moravian Upland) in the central part of the Czech Republic. The mountains are situated to the north from the city of Brno between the towns of Tišnov and Lomnice in the south, towns of Lysice and Kunštát in the east and the town of Nedvědice in the west (Fig. 1). As to the regional geomorphic division of the Czech Republic, the Sýkořská hornatina Mts. represent a geomorphic ward of the geomorphic sub-region of the Nedvědická vrchovina Highland. The mountains are of triangular shape in the plan view. The distance between the northern- and southernmost points is 19 km and between the western- and easternmost points 11 km. They spread on an area of 199 sq. km.

Generally, the Sýkořská hornatina Mts. represent a mountain dome with an elevated flat centre from which slopes are dropping gradually to the west, south and east. The northern boundary with the Vírská vrchovina Highland is less obvious. The highest point of the mountains – Mt. Sýkoř rises in the central part



1 NR Čepičkův vrch a údolí Hodonínky
2 NM Dobrá studně
3 NM Habrová
4 NM Horní Židovka
5 NR Hrádky
6 NM Hrušín
7 NM Kačiny
8 NM Klášterce
9 NM Luzichová
10 NM Míchovec
11 NM Nad Berankou
12 NR Pod Sýkořskou myslivnou
13 NM Sýkoř
14 NM Synalovské kopaniny
15 NM Údolí Chlébského potoka
16 NM Žižkův stůl

Fig. 1: General map of the study area with Specially Protected Areas

to an elevation of 705 meters. In the western part of the mountains there runs a deeply incised valley of the Svratka R. The Svratka R. flows in the narrow tectonic graben filled with Neogene deposits nearby the village of Štěpánovice. Neogene deposits also fill a tectonic graben between the village of Borač and the town of Doubravník. Small remnants of Cretaceous and Neogene clays and sands were found also in the southern part of the Sýkořská hornatina Mts. near the town of Lomnice (Cicha, Dornič, 1958).

Deeply incised are also valleys of the left tributaries of the Svratka R. between the village Štěpánov nad Svratkou (valleys of the Hodonínka R. and the Chlébský potok Creek) and the town of Tišnov (e.g. valley of the Besének Creek). These river valleys deeply dissected the eastern slopes of the mountains.

Geologically, the bedrock is composed of massive porphyroblastic muscovitic and sericitic muscovitic and two-mica gneisses, rarely of biotitic gneisses of the Bíteš group of Proterozoic age. In spite of the apparent uniformity of the bedrock, the study area shows a high degree of geodiversity due to periglacial rocky landforms on tops and slopes. All land surfaces in the study area were underlain by permafrost during the coldest climatic phases of the Pleistocene Epoch. The presence of permafrost and ground ice resulted in a particular group of active geomorphic processes, with their own distinctive landforms. They are all related to the influence of the freeze-thaw cycle and penetration of annual temperature cycles into the ground.

Locality	Degree of protection according the Act No 114/92 Sb.
Sýkoř	Nature Monument
Synalovské kopaniny	Nature Monument
Míchovec	Nature Monument
Pod Sýkořskou myslivnou	Nature Reserve
Horní Židovka	Nature Monument
Čepičkův vrch a údolí Hodonínky	Nature Reserve
Nad Berankou	Nature Monument
Habrová	Nature Monument
Kačiny	Nature Monument
Hrádky	Nature Reserve
Hrušín	Nature Monument
Klášterce	Nature Monument
Luzichová	Nature Monument
Žižkův stůl	Nature Monument
Dobrá studně	Nature Monument

Tab. 1: List of studied Specially Protected Areas with cryogenic landforms (Mackovčin et al., 2007)

3. Definitions

Various authors use some terms in different ways. The authors' usage of these terms is stated below.

Cryoplanation terraces are hillside benches, carved into bedrock. Terraces lack predominant structural control and are formed during periglacial condition by cryogenic processes (frost weathering, congelifluction, nivation). Low-angle treads are separated by rock steps known as frost-riven cliffs or by rubble-covered frost-riven scarps. They often occur in flights, transforming slopes into series of steps. Snow accumulation at frost-riven cliffs and scarps is fundamental for the development of cryoplanation terraces.

Tor is a small castellated outcrop of bedrock on hilltops or slopes. Tors rise above the surrounding gentler surfaces on the hilltops. They occur in two main types, summit (skyline) and sideslope (sub-skyline) tors. Castle koppie is a bedrock outcrop of castellated appearance of larger dimension than a tor.

Nivation hollows are rounded shallow depressions with comparatively steep heads formed by nivation. Kunitsky et al. (2000) distinguished warm and cold based nivation hollows.

Peripediment is a low-angle rock pediment covered by slope and congelifluction deposits.

Past permafrost refers to permafrost of Pleistocene age that does not exist today (French, 2008).

4. Methods

The authors used detailed field geomorphological mapping as a main research method. Products of the ESRI Company ArcGIS 9.2 were used for digital cartographic processing because the system is widely used and allows for advanced data handling.

5. Results

5.1 Cryogenic Forms on Mt. Sýkoř

Mt. Sýkoř represents the highest point of the central ridge of the mountains running in the N-S direction with rocky landforms around the spot height of 705 m a.s.l. (Fig. 2). The ridge is levelled by an extensive cryoplanation terrace in the southern part. The cryoplanation terrace developed at the foot of

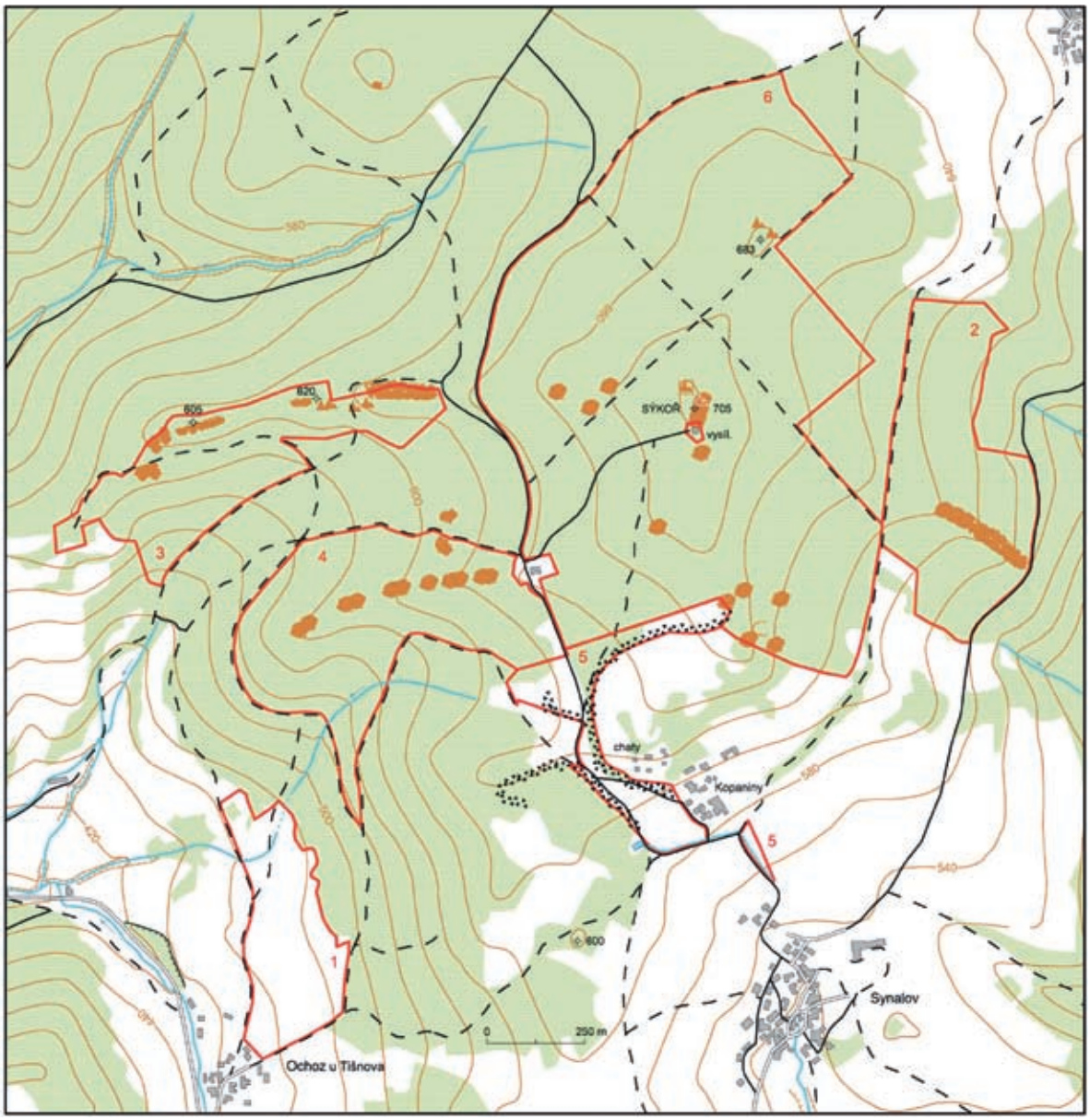


Fig. 2: Digital map of cryoplanation and nivation landforms around Mt. Sýkoř
1 – Nature Monument Dobrá studně, 2 – Nature Monument Horní Židovka, 3 – Míchovec, 4 – Nature Monument Pod Sýkořskou myslivnou, 5 – Nature Monument Synalovské kopaniny, 6 – Nature Monument Sýkoř

the eight meters high frost-riven cliff composed of porphyroblastic muscovitic and sericit-muscovitic gneisses of the Bíteš group. The surface of the cryoplanation terrace is covered by angular blocks. The homogeneous front of the frost-riven cliff is dissected by rock gates and corridors. In the saddle of the ridge, there is an astronomic spot height of 701.7 m a.s.l. To the north-west from this spot height rises a tump of a prismatic form with a flat top delimited by vertical frost-riven scarps with cryoplanation terraces at the foot (Fig. 3 – see cover p. 4). The northern frost-riven cliff is 5.5 m high and the western one is of 9 m (Fig. 4 – see cover p. 4). It is possible that the shape of the western frost-riven cliff face was slightly modified by rock extraction. The top of Mt. Sýkoř was declared a Nature Monument (NM) in 1990.

Slopes of Mt. Sýkoř show step-like formations. A skyline-tor and castle koppie rise there near the spot-height of Malý Sýkoř (683 m a.s.l.). Exfoliation shells and frost-riven cliffs developed on the castle koppie. The overhanging eastern frost-riven cliff is 6.3 m high with a large two meters deep abri at the foot. Debris covers the surface of the cryoplanation flat developed around the tor and castle-koppie (Fig. 2).

The western slope of Mt. Sýkoř is less inclined. Several frost-riven cliffs up to 20 m high and nivation hollows developed on the eastern slope of the mountain. On the southern slope, which is dropping to the Synalovské kopaniny there is a castle koppie in the lower part of the slope. The block streams are up to one kilometer long and several of the huge blocks descend down to

the village of Synalov and give unique beauty to the landscape. Farmers used to collect some smaller rock fragments on pastures and formed agricultural heaps, which have been protected as the Nature Monument of Synalovské kopaniny since 1990.

The Židovka locality is situated on a rocky ridge, which runs from Mt. Sýkoř to the east. Arched frost-riven cliffs developed in the upper part of the ridge and among them, there are sickle-shaped nivation benches. The lower part of the ridge is of a rocky crest running in the NW–SE direction. The ridge is delimitated by frost-riven scarps high up to 10 m. Block streams also developed on the western side of the crest.

The Míchovec locality is situated on a rocky ridge, which runs from the Mt. Sýkoř to the west (Fig. 2). The bedrock appears on the ridge in the form of skyline and sub-skyline tors, castle-koppies, frost cliffs and structural ridges. The rocky ridge is divided by saddles into three parts. Due to a slight dip of gneiss foliation from the north to the south, several expressive frost-riven cliffs developed on the foliation head. Cryogenic processes on the ridge caused downslope movements of huge blocks and therefore the origin of rock falls. These processes resulted in block fields, fissure pseudokarst caves, rims formed by quartz veins, hollows in rock walls and sequences of cryoplanation terraces (length 50 m transversely).

The locality named Pod Sýkořskou myslivnou is situated on a broad ridge running to the southwest from the Mt. Sýkoř (Fig. 2). The ridge is elongated from ESE to WSW between valleys of two nameless tributaries of the Křeptovský potok Creek. Many cryogenic forms of Pleistocene age developed there. The slope of the ridge is less inclined on the NW with several low frost-riven cliffs. The SW inclination is more pronounced with a number of high frost-riven cliffs. There is also a sequence of cryoplanation terraces in the axial part of the ridge at the foot of frost-riven cliffs or scarps and nivation hollows with block accumulation at their bottoms. These terraces range in lengths from 50 m in the upper section to 70 m in the lower section transversely.

5.2 The Hodonínka River valley

The Hodonínka R. is a left tributary of the Svratka R., which empties in the village of Štěpánov nad Svratkou. The Hodonínka R. valley below the village of Hodonín is deeply incised with valley slopes around 200 m deep. Slope inclination varies from 15 to 40 degrees. On the deep and steep valley slopes, there are specially protected parts of nature – Nature Reserve of Čepičkův vrch a údolí Hodonínky and Nature Monument Nad Berankou.

Many cryogenic landforms in gneiss are concentrated in the Čepičkův vrch locality around the Čepičkův vrch Hill (654.4 m a.s.l.) and on the surrounding steep valley slopes (Fig. 5). The ridge around the Čepičkův vrch Hill exhibits the asymmetric cross profile and cryogenic landforms are controlled by the structure of bedrock. The southwest slope is less inclined, the northwest slope is steeper with many frost-riven scarps and nivation hollows. Nivation hollows posse stepped steep rocky walls up to 9 m high (individual vertical steps range from 3 m to 6 m). Forms of backwearing and toppling can be found on the frost-riven cliffs. The Čepička hilltop exhibits a rounded shape and is covered by slab-like congelifracts. The hilltop is restricted by five meters tall frost-riven cliffs on the eastern side. Ptygmatic folds are typical features on these cliffs. A rocky ridge forms the continuation of the hilltop on its eastern side. The NW continuation of the hilltop forms a spur restricted by a row of step-like arranged frost riven cliffs reaching to a height of up to nine meters. The foot of cliffs is overhanging with a nicely developed abris. Nivation hollows with block streams also developed on the slopes as an evidence of nivation processes in the cold periods of Pleistocene. An expressive rocky slope ridge runs from the main ridge in the northern direction to the road bridge over the Hodonínka R. The ridge lowers to the bottom of the Hodonínka R. forming several steps. Frost-riven cliffs alternate with small terrace treads in the longitudinal profile of the rocky ridge. In the cross profile, the ridge is restricted on sides by frost-riven cliffs up to 25 m high. There are apparent folds in gneiss on the frost-riven cliff walls with the exfoliation of onion skin-like slabs. Backwearing of frost-riven cliffs gave rise to small pseudokarst caves. At the foot of the frost-riven cliffs, there were abris created by nivation. Block debris on slopes formed block fields and block streams. The riverbed of the Hodonínka R. is filled with blocks and water forms rapids. In 2002, a disastrous flood caused sudden changes in the riverbed and in the floodplain alluvium.

The locality Nad Berankou is situated on a narrow slope ridge called Na skalách and on a steep slope of the Hodonínka R. valley near the village of Hodonín. The bedrock is exposed on the ridge in low frost-riven cliffs surrounded by block debris. Above the forest road cutting across the ridge, there is an exposed frost-riven cliff 5.2 m high and a downslope of another cliff 9.8 m high. The lower cliff is overhanging with an abri of 1.6 m deep. Downslope there is a castle koppie called Nad hájenkou which is 11.6 m wide. The castle koppie is delimited by a cliff 15 m high used by alpinists as a training rock. Exfoliation forms and a small rock window are also present on the castle koppie. Separated exfoliation slabs sized 2.4 × 1.8 m and 0.4 m thick accumulated on

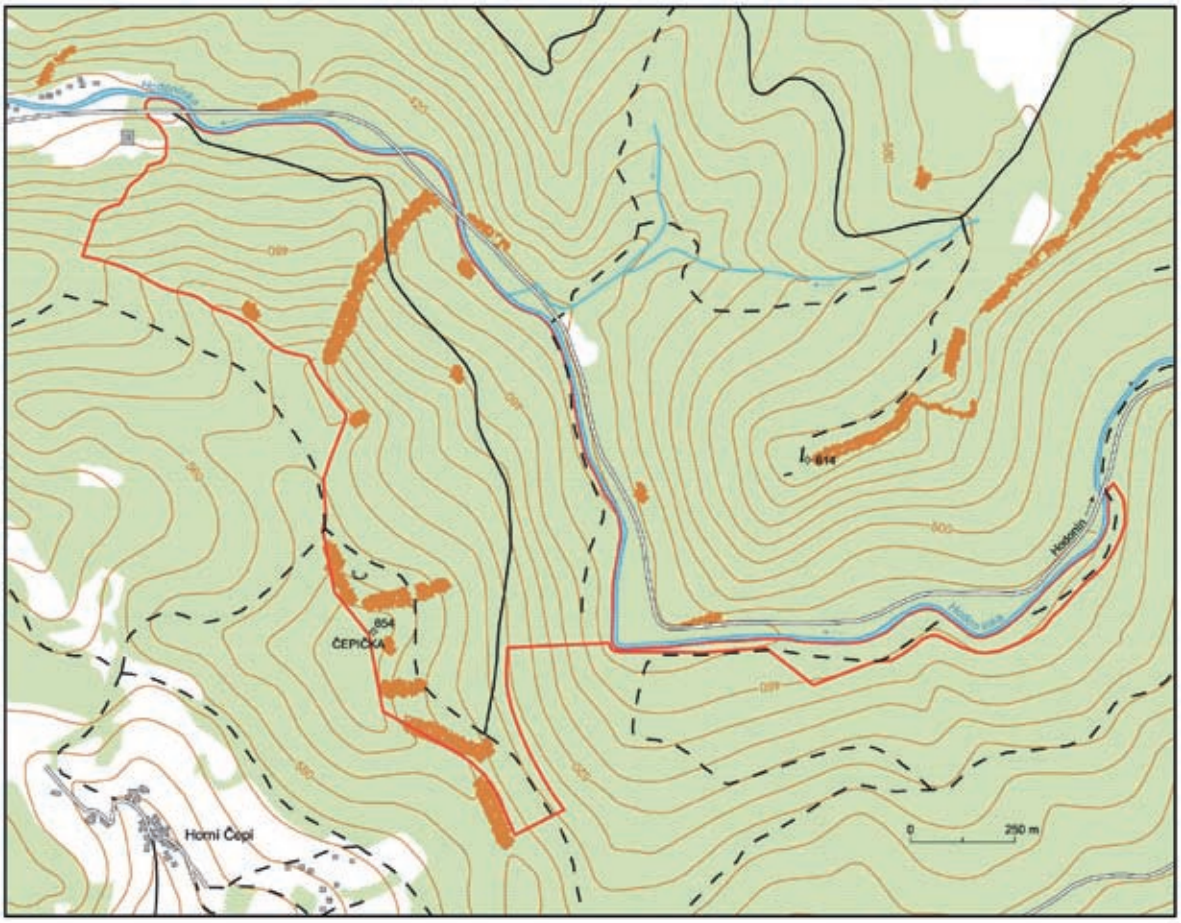


Fig. 5: Digital map of cryoplanation and nivation landforms around the Čepičkův vrch Hill and the Hodonínka R. valley

the slope below the castle koppie. Nivation hollows and with them connected block streams also developed on the valley slope of the Hodonínka R.

5.3 The Chlébský potok Creek valley

The Chlébský potok Creek is a left tributary of the Svratka R., emptying into this watercourse near the town of Nedvědice. In the upper reaches the creek flows in an open valley. Downstream of the village Černovice, the shape of the valley is changing and the creek becomes more incised. In a nice valley, there are numerous Specially Protected Areas also protecting cryogenic landforms (Fig. 6).

The Specially Protected Areas of Habrová and Kačiny are situated on the right valley slope near to the spot height of Záraz (678 m a.s.l.). The Nature Monument Habrová locality is situated on a narrow rocky ridge which runs from the spot height of 646 m a.s.l. to the SE and on the surrounding steep slope (the so called Rampírovy skály Rocks). In the upper part of the right valley slope of the Chlébský potok Creek, a step-like frost-riven cliff rises close to the spot height of 582 m a.s.l., which is about 10 m high and 50 m long. At the foot of the cliff there lie blocks and develop block streams. From the bottom of the nivation hollow with frost-shattered 4.5 m high head wall runs a blockstream. Other high frost-riven cliffs delimitate the ridge from south and east. The frost-riven cliff on the eastern side is 65 m long and 16.3 m high. An undulated congelifluction slope with angular blocks developed there at its foot. Other two lower frost-riven cliffs rose up the slope.

The Nature Monument Kačiny locality is situated on the top of spot-height 640 m. A rocky ridge runs to SSW from the hilltop. The protected area also covers the surrounding steep slopes of the Chlébský potok Creek. The rocky ridge is divided by rock steps into several sections. Gneiss foliation is mostly inclined to the west. On the head of foliation, three rows of rock steps (1–5.3 m high) developed that are divided by narrow treads. The treads are inclined upslope. Therefore, the slope block deformations or other influences of structure cannot be excluded. In the locality, there are nice examples of the Pleistocene frost weathering (frost-riven cliffs, block field and block streams) and of selective weathering (fissure pseudokarst caves, rock shelves, alcoves). Other frost-formed cliffs delimited by debris slopes with angular rock fragments up to two meters long developed on the right steep valley slope of southern aspect.

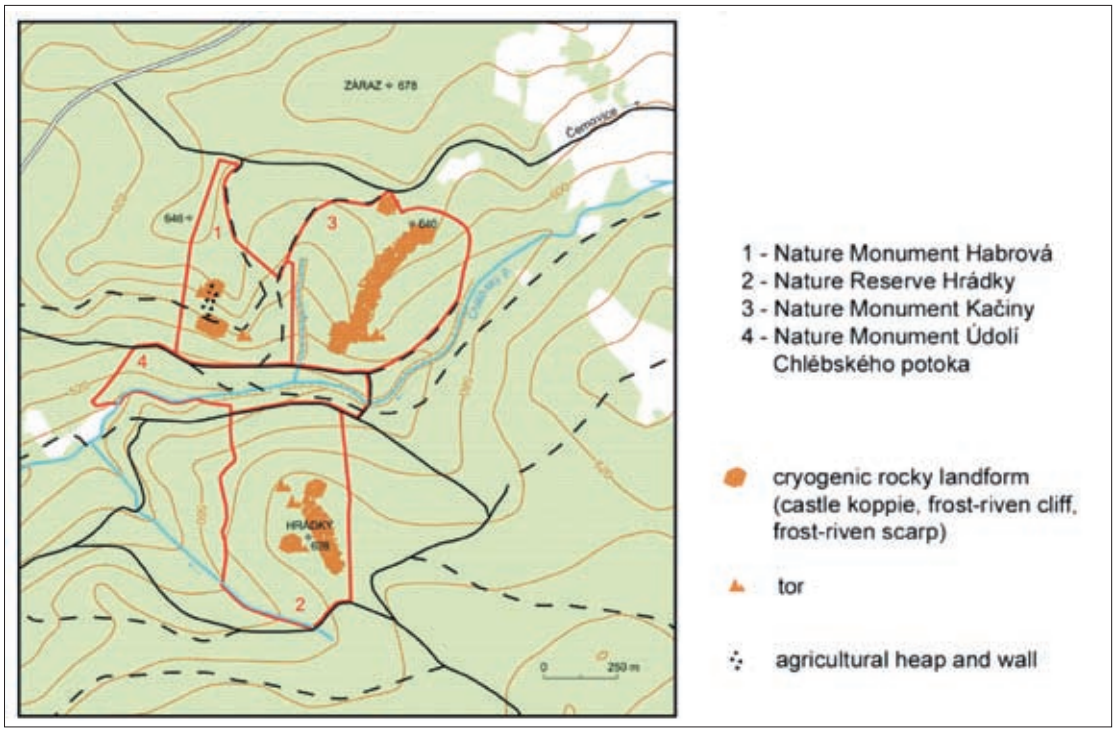


Fig. 6: Digital map of cryoplanation and nivation landforms on the localities of Habrová, Hrádky and Kačiny

The Nature Reserve Hrádky locality is situated on the left valley slope of the Chlébský potok Creek. The core of the locality extends around the spot-height of 627.6 m a.s.l. and on the ridge elongated in the NNW–SSE direction. The group of tor-like rock landforms of a typical mushroom shape developed on the ridge due to frost weathering in the Pleistocene, intensive slope processes and due to the spreading of the ridge (Fig. 7).

The tors are surrounded by the steps of cryoplanation terraces and by frost-riven cliffs in places where bedrock is exposed or thinly buried. The foot of tors is covered by slab-like congelifracts – blocks and stones. Microforms of selective weathering developed on the tors – shelves composed of quartz veins and alcoves developed on the less resistant parts. The southern end of the ridge is formed by two lines of frost-riven cliffs about one meter high. A castle koppie rises on the spot height of 627.6 m. The western and eastern wall of the koppie is 9.2 m and 4.1 m high, respectively. Exfoliation features are present on the castle koppie.

The surrounding of the landform is covered by angular debris. A frost-riven cliff of 8.1 m in height developed on the western slope from the castle koppie with a fissure pseudokarst cave and a nivation hollow. On the NNW end of the ridge raises a gneissic prism (tump) with vertical walls reaching a height of 3 to 5.4 m. On the upper surface of the tump developed a small rock city with a mushroom-like tor six meters high and open fissures. Steps of several cryoplanation terraces developed on the slopes of the ridge.

5.4 The Hrušín locality

The Nature Monument locality is situated in the western part of the Sýkořská hornatina Mts. (see Fig. 1). The core of the locality lies on the narrow, about 0.5 m long asymmetric Hrušínský hřbet Ridge. The Ridge of Hrušínský hřbet is elongated from the N to the S from the spot height of 584 in the N to the spot height of Hrušín (574.0) in the south. The foliation of bedrock gneisses is apparently inclined to the W to the valley of the Svratka R. Rock forms concentrate in the northern part of the ridge. The spot height of 584 m at the northern end of the ridge is delimited by frost-riven cliffs with a large block and a mushroom tor at their foot. Thus, the eastern slope of the ridge exhibits step-like character. On the heads of to the west inclined foliation developed steps of distinctive frost-riven cliffs 4 to 7 m high. Vertical or overhanging frost-riven cliffs are divided by nearly horizontal benches of various lengths. Three distinctive cryoplanation terraces developed in the eastern part of the ridge, which is facing into the Ochozská sníženina Depression. The highest cryoplanation terrace situated immediately below the crest of the ridge is bounded by an ascending frost-riven cliff. The middle part of the cliff has been destroyed by frost weathering and transformed into a block stream. A rocky ridge rimmed on the northern side by frost-cliffs up to eight meters high runs to the NNE from the spot height of 584 m. A cryoplanation terrace developed at the foot of the frost-riven cliffs. An overhanging frost-riven cliff with an abri at its foot forms the end of the ridge. The lowest cryoplanation terrace is bounded by an ascending seven meters high

Fig. 7: Cryoplanation summit flat with a skyline tor in the Nature Reserve Hrádky (Photo J. Ochman)

frost-riven cliff with a slab block accumulation at its foot. Small pseudokarst fissure caves developed in rock landforms.

5.5 The Klášterce locality

The studied locality (Nature Monument) is situated on a narrow rocky ridge elongated in the N–S direction in the southern part of the Sýkořská hornatina Mts. (Fig. 1). The top and the less inclined western slope of the ridge are formed by muscovitic and sericit-muscovitic gneisses, the eastern steeper slope is formed by the Bíteš orthogneiss. A group of small dome-like elevations with small frost-riven cliffs divided by saddles developed on the ridge. The elevations are rimmed by narrow cryoplanation shelves. The rocky ridge is bounded up to 15 m high frost-riven cliff with block debris of the eastern side. An abandoned stone quarry lies in the cliffs. A recumbent fold can be seen on the wall of the quarry.

5.6 The Luzichová locality

The Nature Monument locality spreads on an asymmetric and stepped ridge around the spot height of 481.6 m and surrounds the right slope of the Besének Creek valley. The western slope of the ridge descends into the Ochozská sníženina Depression. The eastern slope of the ridge forms the steep slope of the Besének Creek valley. The valley slope reaches a relative height of up to 150 m and its inclination is up to 40°. The bedrock mostly consists of the Bíteš gneiss, locally with intercalated layers of marbles and graphitic phyllites. The top of the ridge around the spot height of 481.6 m forms a rounded monadnock, which is on the northern side delimitated by frost-riven cliffs. The height of cliffs reaches to 5.9 m with cryoplanation terraces at their foot. About 10 m high frost formed cliffs on the exposures of gneisses developed in several steps on the steep Besének valley slope in the southern part of the locality. At the foot of the cliffs, frost weathering formed block fields. Several nivation hollows, with block streams running from their bottoms also developed on the slope. The walls of the nivation hollow below the spot height of 481.6 m reach a relative height of up to 18.3 m.

5.7 The Žižkův stůl locality

The locality (Nature Monument) is situated in the eastern part of the Sýkořská hornatina Mts. (Fig. 1) and represents an example of the cryogenic re-modelling of a monadnock into a tor, which is typical for the Sýkořská hornatina Mts. There are recumbent folds on the walls of the gneissic tor.

5.8 The Dobrá studně locality

The Nature Monument locality is situated on a low-angle peripediment at the bottom of the Ochozská sníženina Depression. The bedrock is formed of Bíteš gneiss. The surface of the rock-cut pediment descends

from the foot of steep slopes of the Sýkořská hornatina Mts. to the riverbed of the Křeptovský (Ochozský) potok Creek (Fig. 8). The rock pediment surface is covered by congelifluction deposits of Pleistocene age forming a peripediment. Congelifractates formed by Pleistocene frost-thaw action in cold phases of the Pleistocene era accumulated on the rock pediment in the form of coalescing thick debris streams. The tongue-shaped debris streams are mostly 10 to 20 m wide. A congelifluction stream, which is 110 m long and 50 m wide, runs in the central part of the locality (Hrádek, 1999; Lacina, Hrádek, 2001). The individual tongues of the congelifluction streams exhibit telescopic structure. Small marshy depressions filling during the periods of snowmelt and rains with stagnant water developed in front of younger congelifluction streams. Large angular gneiss blocks can be seen at some places on the surface of congelifluction streams.

6. Rock weathering as evidenced by microforms

Permafrost in steep bedrock was abundant in cold periods of Pleistocene in the studied cold-mountain area. Degradation of permafrost caused slope instability in the transition period to warmer climate phases of the Pleistocene and to the Holocene era. It is a well-known fact that the top of permafrost is typically an ice-rich zone. It helps explain the genesis of much of angular cold-climate debris that veneers the vicinity of rock landforms in the studied area. Ice filled fissures were common in bedrock permafrost and possibly actively widened by ice segregation. The convex topography such as summits, ridges, and

Name of the locality	Maximum measured height of frost-riven cliffs
Mt. Sýkoř	20.0
Mt. Malý Sýkoř	6.3
Židovka	10.0
Míchovec	8.0
Pod Sýkořskou myslivnou	15.0
Čepičkův vrch	25.0
Nad Berankou	15.0
Habrová	16.3
Kačiny	15.0
Hrádky	9.2
Hrušín	8.0
Klášterce	15.0
Luzichová	10.0
Žižkův stůl	8.0

Tab. 2: Frost-riven cliffs

Fig. 8: Pleistocene congelifluction streams on the peripediment on locality Dobrá studně (Photo M. Havlíček)

spurs was subject to faster and deeper thaw than other areas. The evidences of these processes are pseudokarst fissure caves, forms of backwearing and toppling on the frost-riven cliffs in some localities. Nice examples of such microforms can be found on the localities of Čepičkův vrch (especially on the distinctive rocky slope ridge that runs from the main ridge in the northern direction to the road bridge over the Hodonínka R.), Kačiny (fissure pseudokarst caves and alcoves), Hrádky (fissure pseudokarst cave) and Hrušín (small pseudokarst fissure caves).

During permafrost thaw at the end of Pleistocene glacial or stadial periods and during climate warming at the end of Pleistocene, the loose bedrock fragments were particularly prone to dislocation (rockfalls) and mass wasting. Block fields and block streams are evidences of many rockfall events that originated from permafrost melting in the steep bedrock (castle koppies, tors, frost-riven cliffs). Block fields developed from rock falls at the foot of frost-riven cliffs in the localities of Čepičkův vrch Hill, Míchovec and Kačiny. Block streams originated in the localities of Mt. Sýkoř, Židovka, Pod Sýkořskou myslivnou, Čepičkův vrch Hill, Habrová and Hrušín. The block streams on the slopes of Mt. Sýkoř are up to one kilometer long and several huge blocks originating from rock-falls descend down to the village of Synalov. Other block streams are connected with nivation hollows (e.g. Nad Berankou, Luzichová). Wonderful congelifluction streams developed in the locality of Dobrá studně.

The origination of rock gates and corridors dissecting the homogeneous fronts of the frost-riven cliffs (e.g. in the Mt. Sýkoř locality) can be explained by the lateral variability of microclimatic conditions in periglacial climate and by the degree of gneiss fracturing. Ground ice-rich fractured zones in bedrock and wide ice-filled fissures to depths of several tens of meters in permafrost were suitable for the formation of above-described rock corridors. Exfoliation microforms originated due to unloading of massive gneiss (e.g. locality Nad Berankou).

Rims formed by quartz veins and hollows in rock walls found in several localities are likely a result of the subsequent re-modelling of cryogenic landforms in the Holocene.

7. Discussion

The Pleistocene cryogenic landforms under study are widespread in the Sýkořská hornatina Mts. In the last decades, several papers were published dealing with cryoplanation and nivation (e.g. Bockheim, Hall, 2002; Czudek, 1995; French, 2007; Hall, 1998; Kunitsky, Schirmeister, Grosse, Kienast, 2000; Nelson, 1998; Reger, 1993), but the discussion about the importance of these processes in periglacial environments is still running (e.g. Hall, 1998; Thorn, Hall, 2002). It is important that this discussion about cryoplanation and nivation in periglacial conditions continues for a better understanding of the Quaternary history of the landscape.

The authors present the opinion that the relict cryogenic landforms in the Sýkořská hornatina Mts. such as cryoplanation terraces, frost-riven cliffs, tors, castle koppies and nivation hollows, are erosion landforms, with a supposedly certain but not predominant structural control.

The relatively homogeneous bedrock in the area under study is composed mainly of the Bíteš orthogneiss of Proterozoic age of the Moravian-Silesian terrane. The gneiss breakdown in periglacial climate had produced enough particles of clay and silt size for congelifluction.

Cryoplanation terraces in the area are low angle bedrock surfaces commonly cut across bedrock structures such as foliation, joints, faults, and shear zones in gneiss and they are covered with a thin veneer of rock debris. However, in some places, the cryoplanation processes may well be steered by the local bedrock structural patterns even in this relatively homogeneous gneiss. Cryoplanation terraces occur in the middle but mainly in the upper sections of hill slopes and slopes of mountains, ridges, spurs and on broad interfluves of the Sýkořská hornatina Mts. Ascending, descending or both frost-riven cliffs or scarps distinctly bound cryoplanation terraces. Terrace benches slope from one (e.g. locality Pod Myslivnou) to seven degrees. These terraces range in length from several to 100 m transversely, and from 10 to 60 m longitudinally. In mountains, the terraces have relatively diffuse patterns without preferred orientation. On hills, ridges and slopes they are discontinuous and do not exhibit strict altitudinal accordance at the individual localities. Cryoplanation terraces in Sýkořská hornatina Mts. often occur in tiered series culminating in summit cryoplanation flats often with skyline tors or castle koppies. The slopes of terrace risers vary from 25 to 90° in places where gneiss is exposed. Some frost-riven cliffs are even overhanging with abris at their foot (e.g. NM Sýkoř). The height of risers varies from 1–2 m (e.g. localities Hrádky and Horní Židovka) to 25 m (e.g. locality Čepičkův vrch Hill). Some frost-riven cliffs are to 50–60 m long (e.g. locality Habrová). Backwearing of frost-riven cliffs resulted in the formation of tumps on hilltops (e.g. localities Sýkoř and Hrádky).

During the observations made on nivation hollows and benches, it became apparent that these landforms were centers of the frost weathering and congelifluction. Frost weathering is a fundamental geomorphological process acting whenever rocks experience a temperature fluctuation across the freezing point and moisture is present. Ground ice formation may generate and propagate micro- or macro-cracks in rocks, and susequent warming and thawing weakens and loosens the fractured rocks (Matsuoka and Murton, 2008). Nivation benches supporting transverse snow patches are common on steep slopes even in the nowadays mild-humid climate.

True bedrock nivation hollows, which contained circular snow patches in periglacial climate are common in frost-riven cliffs and scarps in the Sýkořská hornatina Mts. They belong to the cold-based nivation hollows according to the classification of Kunitsky et al. (2000) and were formed by cold snow patches characterized for the base of permafrost. Nivation hollows create steep, frost-shattered headwalls and are semicircular in the plan view. Nivation hollows do not have any rock basins. Beneath the bottom of the nivation niches lays a considerably thick regolith, perhaps up to four meters deep. For the nivation features under discussion heavy erosion of the niche rock headwalls is typical as well as the accumulation of pro-nival deposits in the central sector of the niches that consists of loose angular blocks or scree and often blockstreams running out of the bottom of the nivation hollows (e.g. localities Mt. Sýkoř, Hodonínka R. Valley, Luzichová). The authors found evidence that snow-patches in nivation landforms were sources of water in the relatively dry Central European periglacial climate of Pleistocene, which supported cryogenic processes, especially congelifluction (congelifluction block streams developed below nivation hollows).

8. Conclusions

The analyzed cryoplanation and nivation landforms in the Czech Republic (Central Europe) developed in periglacial conditions in the presence of permafrost that developed during the cold periods of Pleistocene in the northern mid-latitudes (past permafrost). According to Reger and Péwe (1976) and Reger (1993), the summer temperature in the region was likely to be below 10 °C while the average July temperature was about 4 °C and the average annual air temperature (MAAT) was about -12 °C in the presence of permafrost. The analyzed complex of cryogenic landforms in the Sýkořská hornatina Mts. is a result of deeply entrenched cryoplanation and nivation processes. In spite of some opinions (e.g. Hall, 1998; Thorn and Hall, 2002), cryoplanation is a single process which includes also nivation in the authors' view. Cryogenic processes and cryoplanation landforms are responsible for the high degree of geomorphological geodiversity in the Sýkořská hornatina Mts.

The study area represents a unique combination of morphostructural and morphoclimatic landforms in the Czech Republic. The Sýkořská hornatina Mts. (Mt. Sýkoř 705 m a.s.l.) is neotectonic domal structure with a central graben. Important feature of the region is that the nearly homogeneous lithological composition (gneisses of the Bíteš group of Proterozoic age of the Moravian-Silesian terrane) made it possible to study the relation between structure and processes controlled by periglacial climate of the Pleistocene. In spite of the apparent uniformity of the bedrock, the study area shows a high degree of morphogeodiversity due to the periglacial rocky landforms on tops and slopes and represents the largest mountainous assemblage of periglacial landforms specially protected by the Government under the Act No. 114/1992 Gazette on Nature and Landscape Protection in the Czech Republic. The paper also represents a contribution to international discussion about nivation and cryoplanation.

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Authors' addresses:

Prof. RNDr. Jaromír DEMEK, DrSc. e-mail: *jaromir.demek@vukoz.cz*
Mgr. Marek HAVLÍČEK, e-mail: *marek.havlicek@vukoz.cz*
Mgr. Peter MACKOVČIN, Ph.D., e-mail: *peter.mackovcin@vukoz.cz*
The Silva Tarouca research Institute for Landscape and Ornamental Gardening, v. v. i.
Department of Landscape Ecology and Department of GIS Application
Lidická 25/27, 602 00 Brno, Czech Republic

ENVIRONMENTAL ASPECTS OF SUSTAINABLE DEVELOPMENT IN SLOVENIA

Dušan PLUT

Abstract

With respect to its economic and social indicators, Slovenia ranks among the medium-developed EU countries, but its environmental pressures per capita exceed the planetary acceptable level. The environmental potentials of Slovenia render possible augmentations in welfare and an increase in self-sufficiency, as well as concurrent reductions in ecological footprint. Changes in the field of energy are crucial: it would be necessary to reduce energy consumption and to increase the proportionate utilization of renewable energy resources, with appropriately full environmental responsibility.

Shrnutí

Environmentální aspekty setrvalého rozvoje ve Slovinsku

Z pohledu ekonomických a sociálních indikátorů patří Slovinsko mezi středně rozvinuté země EU, ale jeho environmentální tlak na jednoho obyvatele přesahuje planetárně přijatelnou úroveň. Přírodní zdroje Slovinska umožňují růst prosperity i soběstačnosti při současném snížení jeho ekologické stopy, tj. tlaku na životní prostředí. Zásadní požadované klíčové změny jsou v oblasti energetiky: Je nutné snížit spotřebu energie a zvýšit s plnou odpovědností za životní prostředí podíl využití obnovitelných zdrojů energie.

Key words: *sustainable development, weak and strong sustainability, sustainable development projects, Slovenia*

1. Introduction

Countries all over the world are at an important developmental, social and environmental crossroad. In the second half of the 20th century, the high-entropy developmental path of human civilization, with its intensive use of natural resources and cumulative environmental pressures, began to exceed not only the local and regional environmental capacities but also the planetary ones (Plut, 2002). According to the EU referential energy scenario, the world consumption of primary energy and emissions of greenhouse gases will continue to increase until the year 2030 (EEA, 2008).

Climate change and dramatic reduction in landscape and biotic diversities are the most telling indicators exposing the non-sustainability of increasing material prosperity, assuming we want to preserve conditions for the normal existence of future generations and other species. The current financial, economic and resultant social crisis, which shook people's faith in the omnipotence of market laws, further exposed the false presumption that accumulated developmental, environmental and social problems could be solved in a comprehensive and permanent way by means of traditional neoliberal and related developmental models based on the existing hierarchy of values. Environmental aspects of sustainable development must become an important component in the planning of all material activities and economic development.

2. Sustainable development – an appropriate approach to resolve both environmental and developmental problems?

Numerous experts have established that the total environmental pressures of humankind in the case of climate change, biodiversity reduction and impacts on particular bio-geo-chemical cycles have already exceeded the upper planetary limits and consequently jeopardize the operational capacities of essential components of the Earth's system (Brown, 2008). A comparison between the size of ecological footprints and income per capita shows a high degree of correlation: as a rule, an increase in GDP is associated with an increase in environmental pressures. The answer to the question of whether the humankind will be able to achieve a sustainable balance with the planet in the 21st century will depend on population trends, the use and development of technologies, consumption levels, and types of land use management (Marsh and Grossa, 2002).

Most scientists believe that the present economic growth and developmental models cannot go on indefinitely; new approaches to the use of space and environmental resources are required.

According to Kemp (2004), there are three global modes for the future organization of material life in the 21st century:

a) acontinuation of the present economic model and way of life, which is unfriendly to environment and poorly adapted to the geographical environment ("business as usual");
b) adjusting material activities to the anthropogenic changes of the geographical environment (adjustment scenario);
c) preventively designing the organization of material life based on the principles of sustainability.

Only a balanced world population (stabilization) and balanced economy, with an emphasis on qualitative rather than quantitative economic development, accompanied by a higher rate of employment, continuously operating within the framework of universal spatial and environmental limitations, can ensure our sustainable future survival and rise in prosperity (Daly, 2009).

In its working document EU–2020 Strategy, the EU Commission devised a new developmental strategy, oriented towards a more sustainable, social market economy, with so-called sustainable (economic) growth placed at the centre (Commission of the European Communities, 2009). By the year 2020, progress and a rise in prosperity, especially due to employment possibilities (decrease of unemployment), should take place based on the economic growth but by means of three new key driving forces: innovation (with an emphasis also on eco-innovations), more efficient use of resources, and knowledge. The consumption of resources should gradually decrease (an important developmental shift), which should stimulate economic growth while making possible the achievement of environmental objectives.

The EU, then, supports the implementation of the principles of so-called weak sustainable development, since the key issue is still to support economic growth, primarily by encouraging an increase in eco-efficiency and environmental modernization of the economy, which brings economic and environmental benefits to European industry. The principal issue in general is the gradual introduction of environmental principles into industry, transportation and farming (agro-environmental measures) by means of legal instruments, financial incentives, and voluntary adoption of environment-friendly policies by businesses and institutions (Baker, 2006).

In 2009, the Sustainable Development Commission UK launched an important initiative for considering the entire economic system, the concept of economic growth and its contribution to the prosperity of the United Kingdom and the planet. In this study with the indicative title "Prosperity without Growth", the economist Jackson (2009) calls into question the implementation of continuing economic growth as a driving force for securing wealth, welfare, stability, and employment within the boundaries of respecting environmental limitations. He submitted to the UK Government a number of policies and proposals for the challenging transition to a sustainable society by effectuating the concept of qualitative rather than quantitative economic growth.

Whitehead (2007) concludes that regions are of crucial importance in the process of attaining sustainable development of the nation as a whole. Important are different sustainable regions (or bioregions), which among other things enable the balancing of the needs of cities with those of nearby rural areas. An overall understanding of sustainability within a triangle with equal economic, social and environmental sides therefore underscores the need for sustainable regions which are simultaneously economically successful (economic growth), equitable and environmentally responsible (Glasson and Marshall, 2007).

In the period of crisis, the key objective of the new strategy proposed by "Europe 2020" is the transformation of the economy into a smart, sustainable and inclusive economy, with high levels of employment, productivity and social cohesion. The strategic developmental model of weak sustainability of the EU by the year 2020 is feasible only if all member states, including Slovenia, actively participate.

3. The environmental position of Slovenia

Being an open country and an open material-energy ecosystem, Slovenia can certainly not avoid a critical scrutiny of its developmental and other policies to date, and an intensive search for innovative responses to multi-level challenges in particular. On the eve of the present multi-level crisis, Slovenia, based on current key economic and social indicators (GDP per capita, human development index/HDI), belonged at the national level in the group of most successful world and European countries, ranking at around 30th place. In 2007, GDP per capita in Slovenia was about 27,000 $ (33rd in the world), and according to the HDI indicator (which measures income, education, and life expectancy) Slovenia achieved 26th place globally in 2006. In the 1997–2007 period, the value of the human development index gradually increased, though with

minor fluctuations, and the highest of the values of the so-called sub-indices in Slovenia were those of the attained educational level (UMAR, 2006, 2008).

Ecological footprint is one of the key integrated environmental indicators of the use of natural resources and total burden on the environment, which makes possible a comparison between countries and regions, and indicates strategic environmental-developmental objectives and required environmental measures. In 2005, the average global ecological footprint amounted to 2.7 global hectares (gha) per capita, while the biocapacity of the planet was 2.1 gha per capita, which results in a global ecological deficit of 0.6 gha per capita (WWF, 2008). However, in 2005, the average Slovenian ecological footprint per capita amounted to 4.5 gha (27^{th} place in the world), which means it was more than twice the planetary environmental capacity. As to its HDI (human development index), Slovenia ranks relatively high, at the 26^{th} place, while the index of so-called planetary happiness ranks it at an alarming 79^{th} place; of the economically developed countries, Austria ranks the highest, but not higher than 61^{st} place (New Economics Foundation, 2006).

As to the strategic assessment of developmental potential for sustainable development, Slovenia is characterized by a moderate degree of material prosperity (but with significant and growing social and regional differences). Slovenia is also characterized by a stabilization of population and population pressures on the environment and space; a dispersed settlement pattern with a multitude of small towns and villages; generally abundant water resources; a well preserved natural environment and high-quality residential environment relative to other parts of Europe over most of its territory, and exceptional landscape and biotic diversity. At the same time however, the consumption of natural resources is excessive, and there are various kinds of burden upon the environment and space, including the existence of pockets of intensive and multi-level landscape degradation. The percentage of renewable resources has not increased in the past few years (amounting to about 10% of primary energy consumption); energy and food dependence is increasing; Slovenia has not reduced its emissions of greenhouse gases, transport emissions are especially increasing; landscape vulnerability to climate change is ever greater.

Development reports (UMAR, 2006, 2008) established that in respect of the sustainable development in the most recent period, an improvement is seen in the integration of environmental objectives into the economic development of Slovenia, while the key deficiencies consist of high energy intensity and rapidly increasing road transport and, for Slovenian circumstances (with a small national territory), large and still increasing regional differences. Nonetheless, Slovenia still maintains considerable preservation of environmental capital; high landscape and biotic diversity; territorially (locally and partly micro-regionally) small areas, as a rule, of excessive pressures on the environment and polluted environmental elements; but in the long run also an unacceptably heavy use of natural resources and environmental pollution per capita on a planetary scale (Plut, 2008).

In its use of natural resources and production of emissions per capita, Slovenia (similar to other economically developed European countries) exceeds the planetary permanently acceptable level by two to four times. In the past twenty years, Slovenia has further increased environmental pressures, since its economic development partially took place also by means of environmental capital exhaustion. Nonetheless, a SWOT analysis of possibilities for sustainable development explicitly underscores the numerous comparative advantages of Slovenia and its regions, which surpass some objective disadvantages (Tab. 1).

4. Environmentally crucial proposed projects of sustainable development of Slovenia

An alternative development program (Plan B), prepared by a group of non-governmental organizations and individual experts on sustainable development, proposes for Slovenia, in addition to horizontal measures (e.g. green tax reform, sustainable polycentric development of Slovenia), further groups of environmentally planned developmental projects (Umanotera, 2007): transition to a society with low emissions of greenhouse gases (sustainable energy policy, sustainable transport policy), adjustment to climate change, and rural areas as a competitive advantage of Slovenia.

Among the environmentally crucial guidelines are, besides the increased sustainable use of renewable natural resources, a zero growth in energy consumption and a significant reduction of the ecological footprint per capita by the year 2020. Since the percentage of protected areas in Slovenia is rather high, it would also be urgent to draw up a development project for sustainable management in these areas. Due to the greater use of energy from renewable resources, which is required for environmental protection but partly questionable as to nature conservation, special attention has to be paid to investigating, coordinating, and balancing environmental-protection and nature-conservation arguments as to the extent and mode of use of renewable energy resources. This applies

Strengths	Weaknesses
• Geographical and transport position • Climate—favourable conditions for land cultivation and residence • Generally rich and diverse water resources • Exceptional landscape and biotic diversities • Diversity and capacity of renewable resources and diversity of rural areas • Controllable levels of urbanization and concentration of population and activities • Developed regional identity, long history of stimulation and roots of polycentric development • Mainly reversible forms of environmental degradation • Sectorial and regional traditions of certain forms of sustainable development	• Geomorphologic fragmentation of the territory • High percentage of farmland with limited cultivation possibilities • Modest self-cleaning capacities of the most attractive ecosystems for settlement and development • High dispersion of settlement and building, large areas of suburbanization and decline of most city centres, deficient network of medium-sized towns • Concentration and centralization of economic activities in just certain areas of Slovenia • High percentage of energy- and environment-intensive activities • Excessive (global and local) use of energy and raw materials and resultant environmental pressures per capita • Unexploited developmental capital of protected areas
Opportunities	**Threats**
• Production of healthy food and increase in food self-sufficiency • Sustainable forms of tourism and transport • Sustainable marketing of biodiversity and protected areas • Sustainable and local use of renewable energy resources and other local capital, increase in regional energy diversity, reliability, autonomy and self-sufficiency • Preservation of water resources as a basic strategic commodity in the era of climate change • Positive impact of environmental quality improvement on the health of people and ecosystems • Sustainable regional and polycentric development, preservation of settlement in rural areas and construction of eco-buildings, eco-neighbourhoods and eco-settlements (especially on the thermal zone slopes above the temperature inversion) • Adjustment of environmental pressures to local capacities of the environment and its resources • Development of new environmental technologies and sustainable methods of purification (eco-remediation) • New green jobs	• Jeopardized healthy water supply due especially to intensive agriculture and other pressures on plains (groundwater) • Mass tourism in ecologically sensitive areas • Unsustainable development or reservation-type management of protected areas • Increased use of materials and energy, and building of new centralized energy facilities, with concurrent increase in environmentally questionable use of renewable energy resources • Increase in excessive dispersion of settlement, decline of city centres, and suburban concentration of population and activities only in the Ljubljana basin and Slovenian Istria • Permanent migration and resultant increasing developmental weakness of rural and border areas of emigration • Increasing transport role of cars and road transport of transit cargo • Belated adjustment to climate change

Tab. 1: Strengths, weaknesses, opportunities and threats for sustainable development in Slovenia

particularly to the potential use of renewable natural resources in the Natura 2000 areas, which cover 36% of the Slovenian territory.

According to Novak and Tomšič (2004), the setting up of a new decentralized, sustainable energy system also represents a great opportunity for the scientific and technological development in Slovenia, while a delayed reaction could be fatal and ethically questionable in view of inter-generation relations. In order to implement globally and locally devised sustainable development, Slovenia, in addition to stabilizing energy consumption, has to increase the use of its own renewable resources (including the use of wind and water energy, as well as biomass, solar and geothermal energy). However, this should be in locations, which are not only the most profitable but also environmentally and socially optimal and locally acceptable to the community.

It should be noted that numerous efficient, internationally innovative eco-remediation projects, conceived drawing on rich local knowledge, have already been carried out in Slovenia. In view of the dispersed settlement pattern, water ecology conditions and vast protected areas in Slovenia, eco-remediation as natural processes used for revitalization and protection of the environment (e.g. constructed wetlands) represent the key developmental ecology projects. These are, in fact, eco-innovations, which deserve substantial government support thanks

to their positive effects (Vrhovšek and Vovk Korže, 2007).

Assessments of developmental possibilities and regional resources of Slovenia as a whole and of its regions on the one hand, and the level of depletion of natural resources and current state of the environment on the other, underscore Slovenia's lack of competitive advantages for developing a spatially, environmentally and energy demanding economy. From a developmental and ethical standpoint, it would be an absolute mistake if the present crisis is used as a justification for environmentally unsustainable economic development. Also from the standpoint of environmental resource potential, a crucially important and advisable course for Slovenia would be economic orientation towards environment-friendly products and services, sustainable transport and tourism, production of healthy food, and appropriate ecosystem valuation and marketing of protected areas and their landscape and biotic diversities.

Regarding water resources, the great strategic hydrological advantage of Slovenia should be emphasized. The country has a wealth of diverse water resources, though the gradual lowering of medium and low discharges should also be pointed out (hydrological and agricultural drought in summer 2003), which highlights the importance of wise management of water resources. In comparison with other parts of Europe, Slovenian forests are abundant and well preserved, and they represent an exceptional potential as sources of raw materials and energy as well as for their social and eco-systemic value. Slovenia has no reserves of fossil fuels worth mentioning, but it has a rich mosaic of renewable energy resources, which represent economic and employment capital of exceptional importance. However, to develop them sustainably, a substantial initial financial support from the state and the EU would be required.

Besides the increase in the sustainable use of renewable natural resources, one of the environmentally key starting points to propose the future development of Slovenia is zero growth in energy consumption and a radical reduction of the ecological footprint per capita by the year 2020 (from 4.5 gha per capita to 2.8 gha per capita). Because of the large percentage of protected areas in Slovenian territory, a development project for their sustainable management is also urgently needed.

Fragmented landforms of the Slovenian territory and the resultant smaller self-cleaning capacities of valleys and basins are a geographical environmental determinant (geographical constraint) which sets a limit on excessive (metropolitan) concentration. Nevertheless, from the aspect of the use of natural resources (especially the use of space and energy) and the resultant smaller entropy of their use it also makes possible the recommended "moderate" concentration of population and activities. From the sustainability aspect and from the aspect of preserving the already much reduced cultural landscape, it is reasonable in the transitional period to preserve and stimulate by state funding certain elements of the polycentric-hierarchical system of higher-ranked central settlements (e.g. centres of national importance) as a required supportive regional economic and supply foundation of the otherwise decentralized formation of urban regions. The fundamental strategic sustainable tasks of the policies of Slovenian cities are to restrain suburbanization, preserve the residential function of city centres, limit road transport and develop other forms of environment-friendly transport and improve the quality of the residential environment. A geographical comparison of the regional distribution of investment activities and employees in the so-called creative professions (experts, artists, cultural workers) for the period 2000–2006 shows an intense concentration in the central Slovenian developmental region (explicitly evident in Ljubljana), where two fifths of investments and almost one half of jobs in creative professions in Slovenia were concentrated, though only a quarter of the country's population live in Ljubljana (Ravbar and Razpotnik, 2008). The excessive concentration of population and activities in the Ljubljana basin are harmful from the environmental point of view as well.

In geomorphologically diverse Slovenia, small towns are of exceptional importance in view of general development and polycentric development, and it is small towns that can best adapt to ecosystem mechanisms and environmental capacities and develop the sustainable use of regional resources. Geographical investigation has confirmed the assumption that among small Slovenian towns there is none to display an explicitly unsustainable economic and social development in which the environmental indicators would worsen excessively due to rapid economic growth and efficiency and higher social welfare (Špes, 2007, 2008). However, the disadvantage is, as a rule, that the economically most successful Slovenian small towns are not yet characterized by the highest degree of environmental sustainability, since their urban environmental pressures exceed the planetary acceptable level. As a rule, Slovenian small towns were more successful in adjusting their development to environmental self-cleaning capacities or they avoided major negative impacts on the environment.

In spite of the much wasteful use of energy in Slovenia, high energy intensity and modest reserves of domestic non-renewable energy resources, the following steps are planned in current strategies: increase in energy consumption, increase in CO_2 greenhouse emissions, low percentage of use of renewable energy resources, and increase in energy dependence of Slovenia. In our opinion, a programme for the efficient and reduced consumption of energy should become a key energy-environmental programme for Slovenia.

In contrast, the implementation of decentralized electro-energy scenario for the stabilization and reduction of energy use, which was probably weak as to sustainability at the beginning but sustainably strong after 2020, would bring an initially slower GDP growth for Slovenia, but would be realized within the framework of reliable attainment of planetary and regional environmental capacities by the year 2050, along with a general rise in the quality of life. At the same time, decentralized production of renewable energy resources would increase the degree of self-sufficiency and employment and reliable income of inhabitants in all regions with diverse renewable resources.

5. Slovenia on the challenging and innovative path from weak to strong sustainability

In spite of certain positive environmental emphases, the strategy of development in Slovenia (UMAR, 2005) is basically devised as a developmental model of transition to a model of very weak sustainability, since its main objective is an increase in GDP (growth of several percent annually) and material prosperity, achieved even by depleting its precious and critical environmental capital. However, due to different circumstances (the crisis), exhaustion of developmental models and international environmental obligations to date, Slovenia needs a radically different developmental paradigm, in our opinion: a sustainably planned strategy of development.

In the field of environmental sustainability, Slovenia made a very cautious step, limited to some sectors, from the developmental-environmental phase of limited control over pollution and exhaustion of environmental capital to the second sustainable development phase. T**he developmental phase of weak sustainable development of Slovenia** by the year 2015 is planned to be characterized by limited growth in GDP, very limited substitution of natural capital with created capital, and stabilization or the beginning of gradual reduction of material-energy flows, and energy consumption in particular. Of key importance in this sensitive phase of sustainable development is state support in legislative, financial and educational fields, accompanied by the state's own examples (e.g. green public procurements). The above-mentioned second phase of sustainable development by the year 2015 should also include individual elements of stronger sustainability, especially in the planning of development and nature protection in sizable protected areas and in the promotion of a more prominent role of renewable energy resources.

In view of the excessive Slovenian contribution per capita to global pollution and emissions of greenhouse gases (as a rule, 2–3 times higher than the globally acceptable level), sustainably unacceptable use of non-renewable natural resources, depletion of its own environmental resources and the financial inadequacy of neoliberal high-entropy model, Slovenia should very rapidly move to the next **period of strong sustainable development** (2015–2030).

Quantitatively devised development should be replaced by qualitative development directed towards moderate material prosperity and social security for all inhabitants, devised on the basis of significant reduction of material-energy flows, the intensified use of renewable and other regional resources and decentralization at all levels, regional and local self-sufficiency in supplying commodities relevant for existence, and overall and multi-level adjustment to climate changes. "Green" national and municipal budgets, support for the development of environmental technologies and sustainable activities, effected green tax reform instead of work taxation, autonomy of self-confident innovative regions of critical developmental mass, and intensified environmental education should be the key driving forces for the developmental model of strong sustainability.

In the next, **very strong sustainability period** (2030–2050), Slovenia should reach a high degree of life standard for all inhabitants, with environmental pressures completely within the scope of planetary and local capacities of the environment, with self-sufficiency in the essential fields of existence and with a reliable protection of the biosphere and of other species. We assume that environmental technology and green entrepreneurship, activation of regional resources, sustainable agriculture, sustainable tourism, and "ecologization" of other activities should become a nucleus for the very strong sustainable development of Slovenia. The consumption of primary energy should be significantly reduced, and greenhouse gas emissions should be cut by 80%. The share of renewable energy resources should be greater than the share of fossil fuels.

6. Conclusion

In contrast to numerous other countries, Slovenia has great natural-geographical and environmental capacities, diverse and sufficiently preserved environmental capital to be able – by adhering to a sustainably and innovatively planned path of development for the country as a whole and for its autonomous regions – to achieve multi-level welfare with the use of its own environmental capital at an acceptable level from the standpoint of the planet and entropy considerations by the mid-21st century. Each year of continuation of the current hazardous high-entropy development and settlement model in Slovenia and in other countries of the world further increases the environmental hazard and jeopardizes the survival of our descendants. Slovenia should prepare a low-emission and low-entropy sustainable strategy of development for the country, which should be followed by the operative national developmental programs and regional programs, and be coordinated among sectors.

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Author's address:

Prof. Dr. Dušan PLUT,
Department of Geography, Faculty of Arts, University of Ljubljana
Aškerčeva 2, SI-1000, Ljubljana, Slovenia,
e-mail: *dusan_plut@t-2.net*

DENDROGEOMORPHOLOGY OF SPATIO-TEMPORAL ACTIVITY OF ROCKFALL IN THE FLYSCH CARPATHIANS: A CASE STUDY ON THE WESTERN SLOPE OF MT. SMRK, MORAVSKOSLEZSKÉ BESKYDY MTS. (CZECH REPUBLIC)

Karel ŠILHÁN

Abstract

Research on rockfall activity by dendrogeomorphological methods is a completely new approach to the study of such phenomena in the Czech Republic. The most recent findings concerning a study of rockfalls in the Moravskoslezské Beskydy Mts. are presented in this paper. The methods used included making an inventory of rockfall visual displays and the dating of scars by core drilling. The influence of rock wall character and tree location within a talus cone on the spatial variability of rockfall activity, was established. A curve of rockfall historic activity was created.

Shrnutí

Dendrogeomorfologie prostorově-časové aktivity skalního řícení ve flyšových Karpatech: příkladová studie na západním svahu Smrku, Moravskoslezské Beskydy (Česká republika)

Výzkum aktivity skalního řícení dendrogeomorfologickými metodami je na našem území prakticky zcela nová problematika. Tato studie se tak pokouší přinést nové poznatky ze studia tohoto svahového procesu v Moravskoslezských Beskydech. Byla použita metoda inventarizace vizuálních projevů skalního řícení, a metoda datování jizev z vrtných jader. Byl prokázán vliv charakteru skalní stěny a rozmístění stromů na osypu na prostorovou variabilitu aktivity skalního řícení a byla vytvořena i křivka historické aktivity skalního řícení.

Key words: *rockfall, dendrogeomorphology, spatio-temporal analysis, Moravskoslezské Beskydy Mts., Mt. Smrk, Czech Republic*

1. Introduction

Rockfall represents a type of highly hazardous slope process (Halley, 1984). Despite numerous studies dealing with this problem (Duarte and Marquínez, 2002; Braune et al., 2005; Lan et al., 2007), there is still a large unexplored territory in the Czech Republic. Particularly, the issues of spatio-temporal aspects of rockfall stand for a field of research of high potential. Moreover, the knowledge of these aspects is a very useful tool in the proposal of measures in personal security and protection of property in affected areas.

Dendrogeomorphic methods have recently turned into a highly effective tool in the research of spatial and historic rockfall activity. These methods have primarily been used in the analysis of a few Alpine localities characterized by different physical geographic conditions (Stoffel and Perret, 2006) and they brought high-quality results in all cases. Dendrogeomorphic methods can nowadays be used also to analyze a few-hundred-year-old rockfall (Stoffel et al., 2005a). Nowadays, the rockfall research contributes to the expansion of the application scope of these methods (Stoffel, 2006a) as they have successfully been used in the research of debris flows (Strunk, 1997; Bollschweiler et al., 2007), landslides (Corominas and Moya, 1999; Stefanini, 2004) or floods (Hrádek and Malik, 2007; Zielonka et al., 2008) for many years.

The methods used involve the inventory and dating of scars left on the tree stems by falling rock fragments. However, the spatial display of rockfall differs considerably from other geomorphological processes (e.g. debris flows) as the released moving fragments

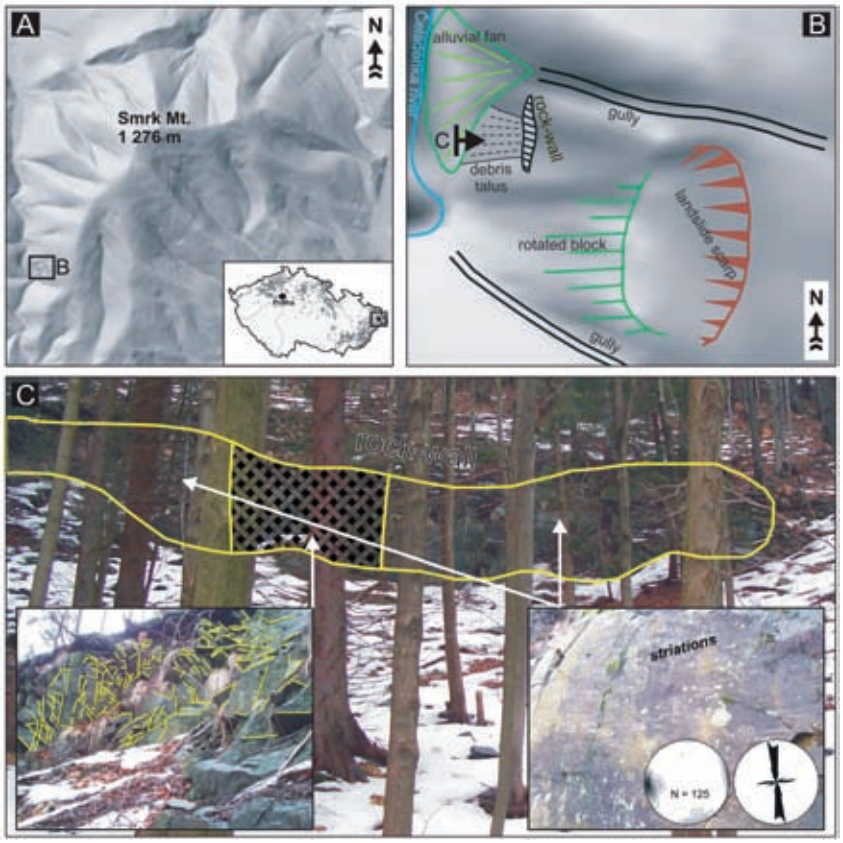
may damage a few trees on their way or they may not hit any tree at all (Stoffel and Perret, 2006). It is practically impossible to determine which of the scars were caused by one single fragment and they thus represent results of one particular event. Moreover, a single tree could have been impacted more than once in a year in which a few scars originated but the identification of individual scars from the increment cores is very difficult. All stem scars that originated within one year are considered a result of a single rockfall event in this study. Consequently, rockfall values are considered to be minimum values (Stoffel and Perret, 2006; Schneuwly and Stoffel, 2008).

The first attempt to analyse rockfall by means of dendrogeomorphic methods in the Czech Republic was presented by Raška (2007). Nevertheless, our paper focusing on a complete rockfall analysis both from the spatial and temporal points of view represents a pioneer study in the field of Czech geomorphology. Its objectives are as follows

a) to verify possibilities for the application of dendrogeomorphic methods in the rockfall research in the Flysch Carpathians,
b) to analyze spatial aspects of rockfall in a selected locality and
c) to create a frequency series of historic rockfall activity.

2. Locality

The locality of the northern slope of Mt. Smrk (1 276 m) in Moravskoslezské Beskydy Mts. (Fig. 1a) was chosen as a case study. It is in the vicinity of the valley floor of the Čeladenka River, which creates a narrow, deep-incised valley with very steep slopes (up to 35 °) between Mt. Smrk and Mt. Kněhyně (1 257 m). The area is built of flysch layers slightly (10–15 °) inclined in the SE direction (Menčík et al., 1983). The locality is situated on the right bank of the Čeladenka River at an elevation of 600–650 m. The rockfall source zone is a ~40 m wide and up to seven meters high rock-wall oriented to W (~270 °) direction and characterized by protruding thick sandstone rocks of the middle member of Godula Formation. The surface of the sandstone rocks shows horizontal striations. The sandstone rocks in the central part of the rock-wall are intensively jointed and sporadically almost disintegrated. The crack analysis showed a prevailing crack orientation almost parallel to the orientation of the rock-wall (Fig. 1c). By contrast, marginal (N and S) parts of the outcrop are formed by a nearly vertical rock-wall with numerous striations (Fig. 1c). The outcrop thus represents an exposed part of a fault zone. A ~40 m long talus cone containing material released from the rock-wall,



Figs. 1A–C: A – Position of the studied locality in Moravskoslezské Beskydy Mts., Czech Republic, B – Geomorphic map of the studied locality with a marked direction of the C image, C – View at the rock-wall from the foot of the talus cone. A detailed photo of two significantly different parts of the rock-wall and a tectonogram of fissures.

consisting primarily of fragments of 25–30 cm, has developed under the wall. In its NW part the talus cone is partly overlaid by an alluvial fan. Its surface has been colonized by a full-grown forest where *Acer pseudoplatanus* prevails over *Picea abies* and *Fagus sylvatica*. This geomorphological situation is found on the forefront of a ~200 m long and slightly rotated block of Godulian sandstones (Fig. 1b).

3. Methods

A few common dendrogeomorphic methods were chosen for the purpose of this study. The first step involved a detailed geodetic localization of individual analyzed trees. The system of geodetic coordinates was used for the spatial interpolation of investigated rockfall parameters and in order to create a DEM of the studied locality. The interpolation method of Kriging in Surfer 8 was applied using a step of one meter.

Further steps involved an inventory of the number of visible tree scars, their elevation above ground level and orientation towards the rock-wall. As no other geomorphic processes were observed in the locality that might have been the cause of the tree scars (debris flows, snow-slides), we suppose that all identified scars were caused by falling rock-wall fragments.

Increment cores were extracted in order to determine the age of both visible and completely overgrown scars. The sampling was based on a well-proven methodology used in the Alpine environment (Stoffel et al., 2005a; Stoffel and Perret, 2006). It involved four increment cores oriented in agreement with the slope gradient, contrary to the slope gradient and facing each other on the stem sides of individual trees (Stoffel et al., 2005a). Sampling height was the medium height of all visible scars, i.e. ~80 cm. The increment cores were subsequently processed in a laboratory by using a standard methodology according to Bräker (2002). They were air-dried, stabilized in wooden channels, flattened and polished. The tree rings were counted and measured using the VIAS TimeTable measuring device. In order to eliminate the influence of climate on the width of tree rings a comparative referential curve was created based on data related to 30 trees growing in the proximity of the analyzed locality, the growth of which was neither affected by rockfall, nor by other geomorphic processes.

The identification of the incidence of scars was based on the direct visual inspection of increment tree-ring curves and on the surface of flattened cores (Fig. 2a) (Schweingruber, 1996). The attention was focused on a sudden narrowing of tree-ring widths as a consequence of

a) the appearance of a scar,
b) the tree chop-off (Fig. 2b)

and on abrupt growth release as a consequence of the decreased competition due to the death of a neighbouring tree (Fig. 2e) or tree inclination accompanied by the occurrence of reaction wood.

The observation included the presence of callus tissue at the scar margin that helps the tree to join

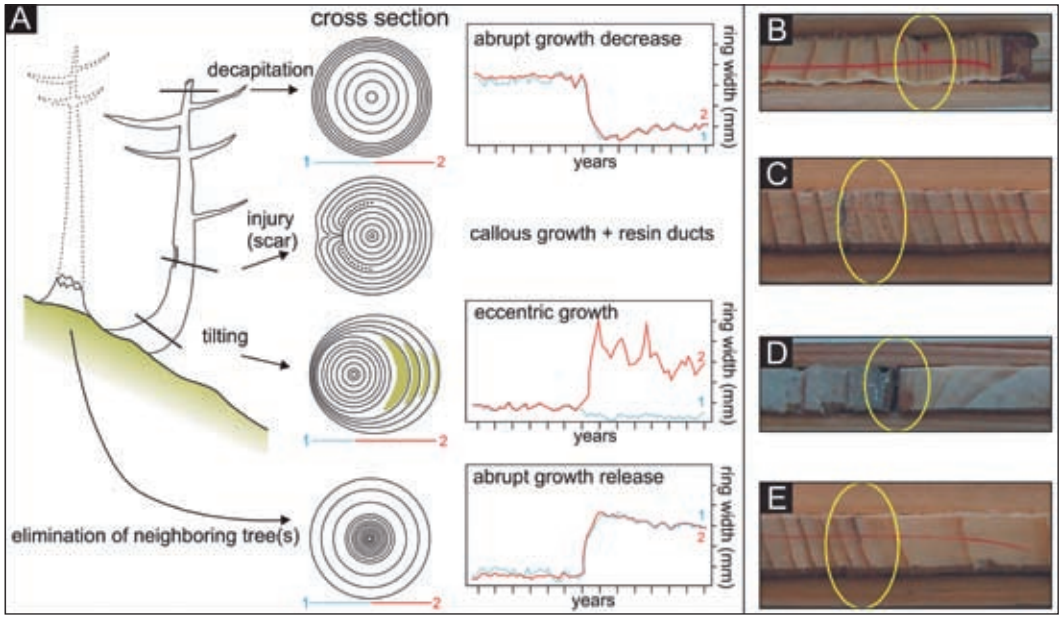


Fig. 2: Increment tree-ring deformations used in the identification and dating of scars (adapted after Stoffel et al., 2005a). A – Scars on trees and their reflection in the tree-rings, B–E – The display of scars in processed increment cores (explained in the text).

up the scar (Fig. 2d). A significant scar indicator is the occurrence of Traumatic Resin Ducts (TRD) in tree rings (Fig. 2c) in years following the impact (Stoffel, 2006b; Bollschweiler et al., 2008b). Not all TRDs can, however, be considered as the scar evidence. The dating involved rather large TRDs that formed continuous sequences and appeared in a few consecutive years (Stoffel et al., 2005a; Schneuwly et al., 2009a; Schneuwly et al., 2009b).

Chronology of the rockfall activity was expressed by means of the 'rockfall rate' indicator defined as a number of dated scars per one meter of diameters of all trees sampled in a given year (Stoffel et al., 2005a) and its formula is:

$$RR_y = \sum S_y / \sum D_y,$$

where RR_y is 'rockfall rate' in the given year, S_y represents scars dated in the same year and D_y represents all tree surfaces in the given year.

The 'rockfall rate' values for individual trees needed in the spatial analysis were calculated as follows:

$$RR_t = \sum S_t / (r_t \,.\, A_t),$$

where RR_t is 'rockfall rate' of the tree, r_t is the tree radius, A_t is the tree age and S_t is the number of dated tree scars.

4. Results

Inventory of visible tree surface damage

A total of 57 trees growing on the talus cone surface were visually analyzed. The dominating species was *Acer pseudoplatanus* (39 trees), followed by *Picea abies* (12 trees) and *Fagus sylvatica* (6 trees). The number of visible scars reached 431 with an average of 7.6 events per tree. The average height of scars above the land surface was 82.6 cm, whereas the highest scar was observed 300 cm above the ground level. The average scar length was 11.9 cm. On average, the longest scars were observed on *Picea abies* (18.8 cm), while the shortest ones on *Fagus sylvatica* (6.8 cm). The results are given in Tab. 1.

Spatial aspects of visible scars

The spatial distribution of visible scars shows that a majority of scars were found on stems in the proximity of the rock wall (Fig. 3a). Numerous scars on the tree stems were also situated in the central part of the talus cone, in the upper part of which was the density of trees very sparse. Another tree cluster showing a high number of scars (11–14) was also observed in the lower part of the talus cone. On the other hand, the fewest scars occurred on the lateral peripheries of the talus cone as well as on the trees growing at lower fringes of denser tree clusters. The average scar height on stems was highest in the proximity of the northern fringe of the rock-wall and along lateral fringes of the talus cone. The lowest average height was measured in the proximity of the central and southern parts of the rock wall and in the central part of the talus cone (Fig. 3b). The maximum scar height occurring on the stems corresponded with this spatial distribution (Fig. 3c).

The scar orientation on stems towards the rock-wall position showed a dominant position of scars in the direction that was nearly vertical to the rock-wall (Fig. 3d). A minimum of scars occurred on the sides of trees or on their rear sides.

Tree sampling

Increment cores were taken from 42 trees owing to wood rot and a very small diameter of some tree stems. However, a total number of sampled increment cores was 168. The average age of sampled trees was 45.3 years, whereas the oldest tree was 57 years old and the youngest one 25 years old (Tab. 2). The average stem width was 26.9 cm. The mean annual increment value was highest in *Picea abies* (0.78 cm/year), while the lowest value was measured in *Fagus sylvatica* (0.37 cm/year). The average value then made 0.58 cm/year.

Scar dating

Most scars were identified in boreholes inspecting the results of the sudden narrowing of tree rings (37.9%). Sudden growth releases revealed a comparable amount of scars (23.5%), as well as the presence of callus tissue (25.7%). The fewest scars were identified by means of Traumatic Resin Ducts

Number of scars	Scars per 1 m of diameter	Average length of scar (cm)	Average height of scar (cm)	Maximal height of scar (cm)
69	5.7	18.8	90.0	300
299	7.6	11.4	83.5	210
63	10.5	6.8	72.8	200
431	7.6	11.9	82.7	300

Tab. 1: Results of the inventarization of visible tree scars

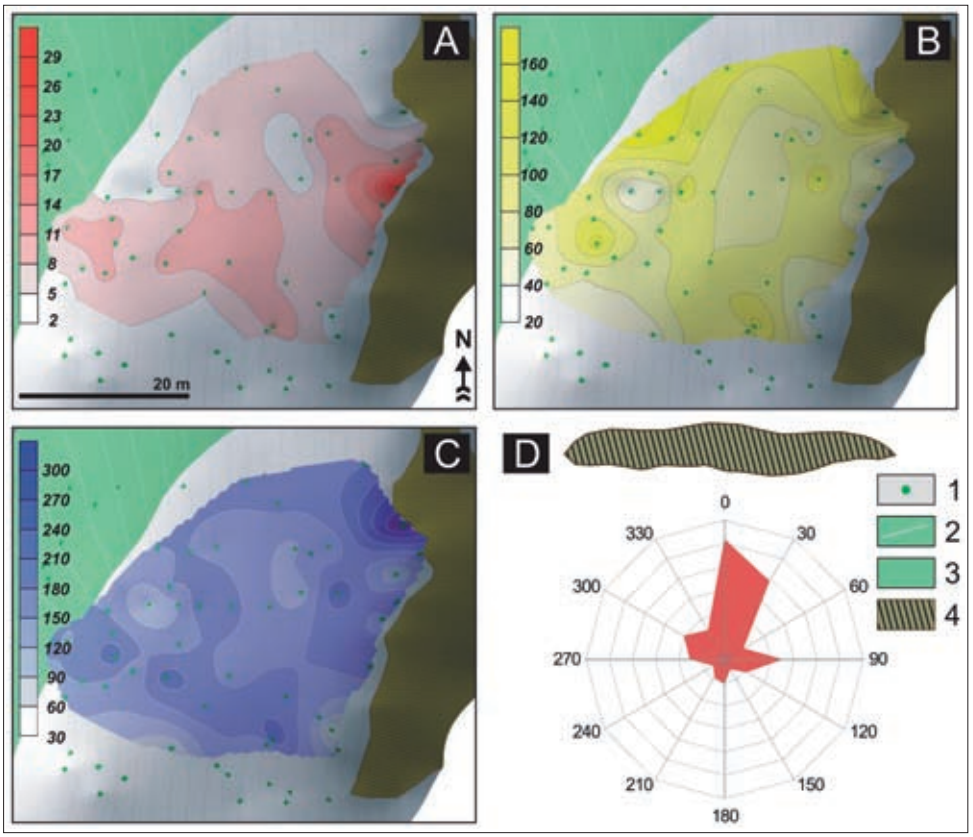


Fig. 3: Spatial aspects of visible scars on the surface of tree stems. A – A number of visible tree scars, B – Mean height of tree scars (cm), C – Maximum height of tree scars (cm), D – Orientation of scars towards the rock wall (°), 1 – Tree position, 2 – Contour lines (1 m), 3 – Alluvial fan, 4 – Rock wall.

	Number of sampled trees	Average age (years)	Maximal age (years)	Minimal age (years)	Average width of stem (cm)	Average year increment (cm)
Picea abies	12	46.6	56	36	35,9	0.78
Acer pseudoplatanus	29	44.7	57	25	23,2	0.51
Fagus sylvatica	1	45.0	45	45	16,5	0.37
all	42	45.3	57	25	26,9	0.58

Tab. 2: General characteristics of sampled trees

	Abrupt growth decrease	Abrupt growth increase	Traumatic resin ducts TRD	Callus tissue	Total
growth disturbances (%)	37.9	23.5	12.9	25.7	100
growth disturbances (number)					181

Tab. 3: Percentage representation of all scars evidence in increment cores

	Number of cores	Number of growth disturbances	Number of reconstructed scars	The oldest reconstructed scar
Picea abies	48	75	46	1964
Acer pseudoplatanus	116	102	76	1962
Fagus sylvatica	4	4	3	1986
all	168	181	125	1962

Tab. 4: Results of the identification of scars in boreholes

(TRD) (12.9%). The total number of dated events reached 181 (Tab. 3). With regard to the fact that some scars were identified using secondary indicators (e.g. abrupt growth decrease and/or TRD) or in more cores of identical tree, it was necessary to modify their number to eliminate double displays.

The resulting number thus made a total of 125 dated scars, of which 46 scars were dated on *Picea abies*, 76 scars on *Acer pseudoplatanus* and three scars on one *Fagus sylvatica*. The oldest scar originated from the year 1962 (Tab. 4).

Spatial aspects of dated scars

The talus cone showed an even distribution of trees of various ages; no tree clusters were observed. Older trees occurred especially in the northern part of the talus cone (Fig. 4a). The highest number of dated scars was dated in the increment cores of trees on the northern fringe of the talus cone, whereas the fewest scars were dated in the lower part of the talus cone and in the proximity of the northern part of the rock-wall. The remaining parts of the talus cone showed on average 2–4 scars per tree (Fig. 4b).

The average time interval between the origin of two scars (tree age/number of dated scars) was low at the talus cone fringes as well as in the proximity of the central part of the rock wall. On the contrary, the longest time interval was measured in trees growing in the lower part of the talus cone (Fig. 4c). The highest 'rockfall rate' values appeared in the proximity of the central part of the rock-wall but they were decreasing with the fall line. An exception was represented by two trees with the increased 'rockfall rate' value, which grew in the lower part of the talus cone (Fig. 4d).

'Rockfall rate'

The 'rockfall rate' (RR) time path was studied in 42 trees (sample depth). Analysing the identical number of dated scars in individual years, values of this indicator depended indirectly on the total exposed diameter of all trees growing in a given year (exposed diameter – ED, Stoffel et al., 2005a).

Its values also became less objective if the number of analyzed trees was very low. In this case, the limit of credibility was determined as a value corresponding to 30% of the exposed diameter of 2008. This limit was exceeded in 1975. The RR time path is shown in Fig. 5.

Because it was quite unbalanced in the individual years, its values were balanced by means of a moving

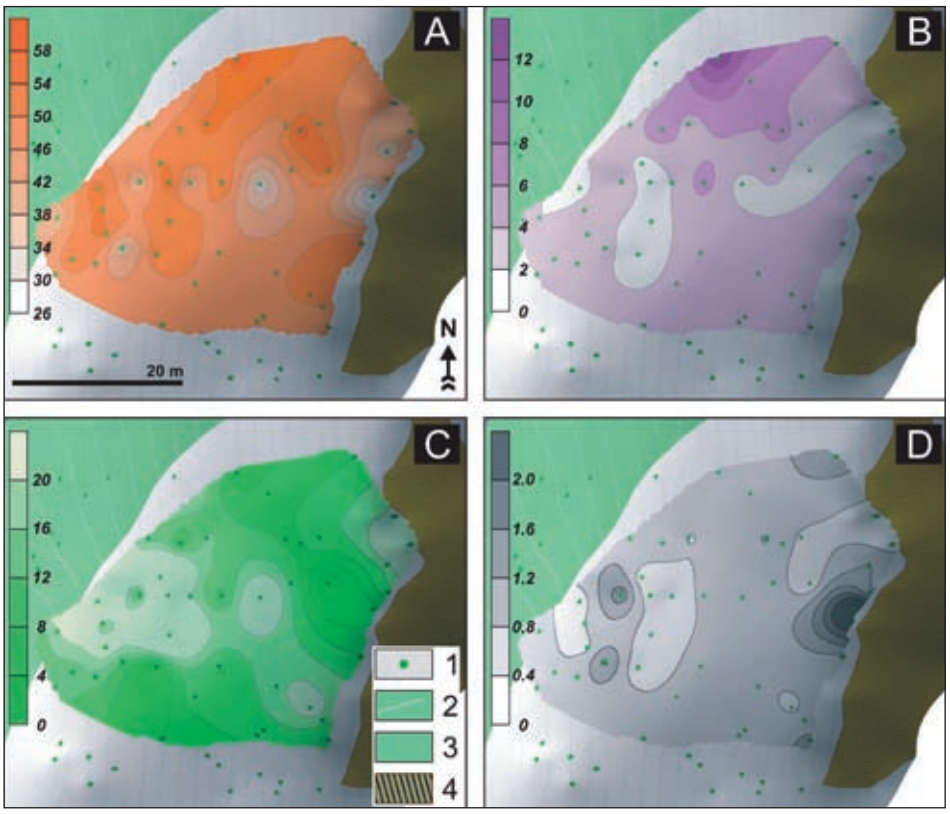


Fig. 4A–D: A – Age of tree on the talus cone (years), B – Number of dated scars per tree, C – Average interval of scar occurrence (years), D – "RR" values (scars . year^{-1} . m^{-1}), 1 – Tree position, 2 – Contour lines (1 m), 3 – Alluvial fan, 4 – Rock wall

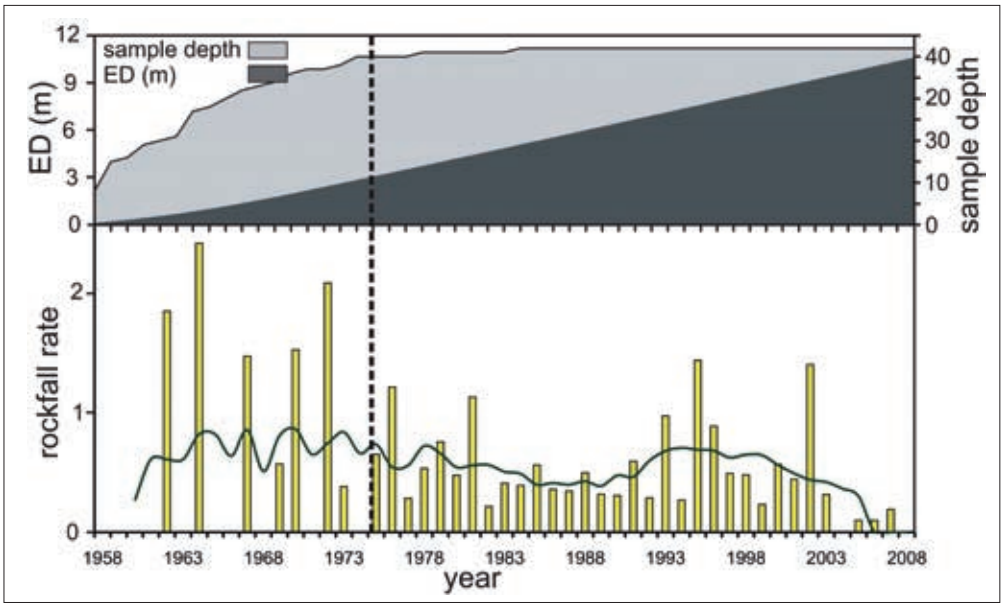


Fig. 5: Rockfall time development. "Rockfall rate" annual values (scars . year^{-1} . m^{-1}) (in a yellow colour) and their average over five years (black line). Development of stem exposed diameter (ED) depending upon the number of analyzed trees (upper part of the figure). The border of a minimal exposed diameter (30% ED from 2008) and "RR" curve relevant values (vertical discontinuous line).

average calculated for 5 years. The starting year is 1977 and the terminal year is 2006. The moving average shows a slight decrease in the rockfall intensity from 1977 to the mid-1980s. It increased in the early 1990s and culminated in the mid-1990s when a decrease started again.

5. Discussion

The survey of the surface of 57 trees revealed a total of 431 scars. The largest scars were recorded on the trees of *Picea abies* (18.8 cm), unlike 6.8 cm on *Fagus sylvatica*. The number of visible scars on *Picea abies* was lower than on *Fagus sylvatica*, as well. This finding is supported by the fact that in comparison with *Fagus sylvatica*, *Picea abies* has thicker bark, which significantly softens the energy of a moving fragment (Stoffel, 2005).

Thus, wood is damaged only when hit by a large fragment characterized by high dynamics. As a result of this, the average size of scars on the *Picea abies* trees is almost three times higher than on the *Fagus sylvatica* trees, whose surface may be damaged even by a relatively small fragment. A smaller number of visible scars on *Picea abies* can also be caused by the species' high annual increment values (Stoffel and Perret, 2006). *Picea abies* trees increment value of 0.78 cm a year indicates a much faster joining up of smaller scars than in the case of *Fagus sylvatica* trees increment value of 0.37 cm/year. The annual increment value of the trees (0.58 cm) corresponds to values measured on trees affected by rockfall (Stoffel and Perret, 2006).

In comparison with other studies (Stoffel, 2005), both the average (82.7 cm) and the maximum (300 cm) heights of scars are lower. The explanation can be a small rock wall height, a relatively small gradient of the talus cone and, as compared to Alpine areas, a shorter transport distance of moving fragments.

The comparison of the number of dated scars in increment cores also brought interesting results. While 48 *Picea abies* trees featured 46 scars, 116 *Acer pseudoplatanus* trees showed only 76 scars. In this case, more scars on average were identified on the individual *Picea abies* trees than on the *Acer pseudoplatanus* trees. A possible explanation is a different physiological response of coniferous and deciduous trees to scars (Schweingruber, 1996). Both groups of the tree species respond by means of a similar type of ring deformations. An exception is observed in connection with the response of the wood of tilted trees because conifers develop compression wood on the stem side, which is opposite to the side where deciduous trees form tension wood (Stoffel and Bollschweiler, 2008).

In this respect, a fundamental difference is related to the formation of traumatic resin ducts that appear as a reaction to scars only in certain conifer species (Stoffel, 2006b). This evidence is thus absent in the identification of scars on broad-leaved trees. Bollschweiler et al. (2008a) use this evidence to date up to 50% of all scars and Perret et al. (2006b) even up to 70% of all scars in conifers. The comparison with the *Fagus sylvatica* species is irrelevant as the analysis involves only one *Fagus sylvatica* tree.

The majority of visible scars were found in the proximity of the central part of the rock wall. This part of the rock-wall shows very intensive rock jointing, even disintegration, which points to a higher frequency of fragment fall-off in this part and to a higher number of scars on the nearest trees. The higher rockfall intensity in this part is also supported by a significant "bite-off" of the rock-wall bottom in its ground-plan position. On the contrary, the fewest scars were found on trees that were in close alignment with trees growing higher up the slope. Stoffel et al. (2005a) refer to this as to a kind of protection effect of trees located in higher elevations.

A higher amount of scars found on trees in the central part of the talus cone was most likely caused by the absence of this effect as practically no trees capable of capturing the fragments occur between the trees in the central part of the talus cone and the rock wall. A small number of scars in the proximity of the talus cone fringes was explained by the character of the rock wall which is only slightly fragmented by cracks in these zones and which, in its northern part, passes into an almost vertical wall with striations. It is exactly the irregular tree distribution on the talus cone and the non-homogeneous rock wall character that cause anomalies in the spatial number of scars. Therefore, no significant dependence can be found between the number of scars on trees and the distance of trees from the rock wall ($r = -0.167$) or the stem diameter ($r = -0.097$) (Fig. 6), which is also proved by the research of Perret et al. (2006a).

The highest average height of scars on trees in the proximity of the northern part of the rock wall can also be connected with the rock wall height and with the character of protruding rocks. The rock wall is loosened only in the upper part of the outcrop and therefore rock fragments reach the tree surface falling from a relatively considerable height. The great average height of scars at the talus cone fringes can be explained by the movement of rock fragments down the talus cone in the form of rolling, sliding and especially bouncing, which can accelerate particularly at the talus fringes due to the low density of trees growing there.

The assumption that all tree scars originated following a rockfall activity is supported by the dominating orientation of scars that is vertical towards the wall. Very few scars on tree sides or rear sides may have originated through rock fragment bouncing off other trees and changing in their trajectory (Stoffel and Perret, 2006). Age distribution of trees on the talus cone (with older trees in its northern part) roughly corresponds with the number of scars in the respective increment cores. The higher number of dated scars on older trees indicates that these trees were longer exposed to moving rock fragments.

The recurrence interval of the origin of individual scars is again highest in the proximity of the central part of the rock-wall, which proves a high rockfall activity related to this area. On the contrary, the occurrence of scars in the interval of more than 20 years in the lower part of the talus cone indicates a gradual fade-out of the impact of falling rock fragments with the increasing distance from the rock-wall.

All these spatial aspects are supported by the distribution of the 'rockfall rate' values on the talus cone surface. Maximum values reached in the proximity of the central part of the rock-wall are represented by more than two scars . year^{-1} . m^{-1}. The gradual decline of values down the talus cone thalweg to below 0.4 scars . year^{-1} . m^{-1} proves the hypothesis of the decreasing rockfall activity with the increasing distance from the source of fragments (Schneuwly and Stoffel, 2008).

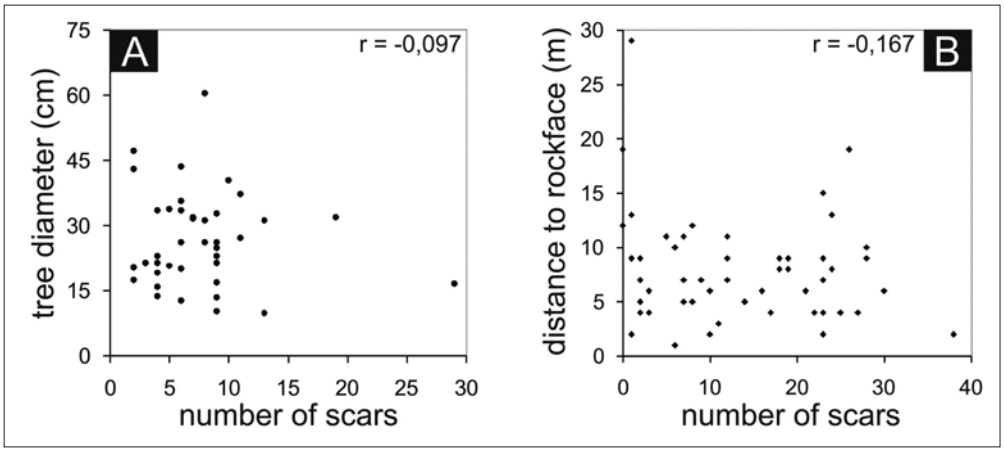


Fig. 6: Graphical representation of relations between the number of visible scars on a tree stem and its diameter (A) and the distance of the tree from the rock wall and the number of visible scars on the tree surface (B)

Trees growing on the talus cone are very young (45.3 years old on average). No remainders of older trees (e.g. tree stumps) were found, which is limiting for the maximum length of rockfall activity record on the talus cone (~30 years). However, as compared with other analyzed localities it does not represent a very short range. For example, Stoffel et al. (2005a) obtained a range of 'rockfall rate' values for a period of 400 years. Other data can provide even shorter ranges (e.g. 50 years, Schneuwly and Stoffel, 2008). A smooth time curve of 'rockfall rate' values is a useful tool in the analysis of rockfall controlling factors. Further research should thus incorporate a more detailed analysis of the development of the curve, namely as compared with climatic data. The comparison with the time path of various climate variables proved a strong relation to e.g. average winter and summer temperatures (Stoffel and Perret, 2006), extreme rainfall (Schneuwly and Stoffel, 2008) or other factors such as human activity on slopes (Stoffel et al., 2005b).

6. Consclusion

The presented study brings new findings on the spatial and temporal rockfall distribution in the Flysch Carpathians. Answers to the questions asked in the introduction of our paper can be summarized as follows:

- Possibilities of the dating of both visible and hidden scars caused by rockfall were verified by means of dendrogeomorphic dating. In this respect, coniferous trees appear to be more suitable considering their ability to create traumatic resin ducts. However, despite the fact that it concerns rather larger fragments of higher dynamics that leave visible scars on the surface of conifers, the scars overgrow relatively quickly.
- The spatial analysis of rockfall aspects showed an important effect of the character of the rockfall source area on the distribution of its displays (scars). The most affected areas are found in the proximity of a very jointed, almost disintegrated rock-wall. On the contrary, high smooth walls become fragmented only sporadically, namely in their summit parts. The spatial distribution of scars is also influenced by the protective effect of trees, which "screen" the lower positioned trees. A combination of these factors contributes to decreased rockfall activity farther from the source of material.
- The experimentally created rockfall activity sequence demonstrated a significant fluctuation in the course of its intensity because periods of higher and lower rockfall activity are evident in the reconstructed record of ~30 years. Further stages of the research are intended to incorporate a comparison of time data with the climatic records and to identify factors initiating the rockfall.

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Author's address:

RNDr. Karel ŠILHÁN, Ph.D.
Department of Physical Geography a Geoecology, Faculty of Science, University of Ostrava
Chittussiho 10, 710 00 Ostrava, Czech Republic
e-mail: *karel.silhan@osu.cz*

LAND USE CHANGES IN THE SUBURBAN ZONES OF BANSKÁ BYSTRICA AND ZVOLEN (SLOVAKIA)

Daniela VIGAŠOVÁ, Ľubica PAPAJOVÁ-MAJESKÁ, Lucia KRÍŽOVÁ, Martin ŠVEDA

Abstract:

Suburbanization is one of the contemporary processes which significantly transforms the landscape and changes the spatial organization of society. In the Slovak environment, the effects of suburbanization can be traced in the surroundings of the largest cities, in which a major part of their activities are shifted into the adjacent hinterlands and thus create new spatial structures. The objective of this paper is to examine the spatial structure of land use in the surroundings of the Functional Urban Regions (FURs) of Banská Bystrica and Zvolen. Using a baseline, a detailed comparison of data obtained from the database Aggregate Areas of Land Types (Úhrnné hodnoty druhov pozemkov) was used to analyze changes in land use in 42 municipalities of the FUR Banská Bystrica and 45 municipalities of the FUR Zvolen.

Shrnutí

Změny využití krajiny v suburbánní zóně Banské Bystrice a Zvolena (Slovensko)

Suburbanizace je jedním ze současných jevů, které významným způsobem přetvářejí okolní krajinu a mění prostorovou strukturu společnosti. Ve slovenském prostředí můžeme sledovat její projevy v okolí největších měst, a to konkrétně v zázemí měst, kde tento proces vytváří novou prostorovou strukturu okolní krajiny. Cílem tohoto článku je sledovat suburbanizaci prostřednictvím změn ve využívání krajiny ve funkčním městském regionu (FMR) Banské Bystrice a Zvolena. Na základě srovnání údajů „Úhrnných hodnot druhů pozemků" (UHDP) jsme analyzovali využití krajiny ve 42 obcích FMR Banská Bystrica a v 45 obcích FMR Zvolen.

Key words: *suburbanization, land use changes, municipal spatial structure, Functional Urban Region Banská Bystrica and Zvolen, Slovakia*

1. Introduction

Land cover is a material manifestation of natural and socio-economic processes associated chiefly with land use (Feranec, Oťaheľ, 1999). In recent years the changes to land cover were influenced by continuing differentiation in the functions of core centres (cities) and their peripheries (hinterlands).

The countryside adjacent to the core centres is subject to dynamic transformation leading to extensive land use changes. Functions hitherto peculiar only to urban regions come to play an important role in the rural regions of agricultural nature.

Suburbanization is a dominant process reshaping the hinterland landscape. Several authors have addressed this issue – e.g. Matznetter, 2004; Berényi, 1997; Herfert, 1997; Matthiesen, 1998; Durydiwka, 2003; Obloza, 2003 and others. Czech and Slovak cities started to be impacted by the suburbanization processes since the early 1990s (Matlovič, Sedláková, 2004; Korec, 2006; Slavík et. al. 2005; Ouředníček, 2003; Mulíček, 2002).

According to Matlovič and Sedláková (2005) one of the outcomes of suburbanization is increasing built-up area (habitable surface area) in the suburban zone of the cities. The migration of the city population to its hinterland takes place in the process of which the central city loses its inhabitants to the hinterland. This residential form of suburbanization usually goes hand in hand with commercial suburbanization characterized by the shift of services, business and manufacturing activities towards the suburban zone. The biggest attention of not only geographers but also urbanists and environmentalists is drawn to the dynamical processes of residential and commercial suburbanization.

Views and approaches to suburbanization processes vary in literature. In his study Šveda (2009) mentions three main approaches to suburbanization identification:

1. changes in distribution of population between the city and the suburban zone,
2. changes in demographics and social factors of inhabitants living in the hinterland (socio-demographic approach), and
3. land use changes in the suburban zone (morphological approach).

The first two approaches were the focus of the majority of the Czech and Slovak research papers, whilst the third approach (morphological) has not received much attention (Bičík, Kupková, 2006; Chuman, Romportl, 2008; Feranec, Oťahel, 1999; Feranec, 2008; Feranec et al., 2010). The third concept prevails chiefly in the United States (Galster et al., 2001; Ewing et al., 2002) where suburbanization is marked by different forms and spatial extent than in European cities. Despite variations between the European and American environments we can draw inspiration from some of the American approaches in our conditions (in the Czech and Slovak environments – Sýkora, 2003).

The paper sets out to scrutinize the spatial structure of land use (from the morphological perspective) in the environs of Banská Bystrica and Zvolen where a great degree of suburbanization is underway (Šveda, Vigašová, 2009). Based on the comparison of detailed data from the Aggregate Areas of Land Types (AALT) database for the years 2000–2008 we analyzed land use changes in 42 municipalities of the Functional Urban Region (FUR) Banská Bystrica and 45 municipalities of FUR Zvolen. Our focus was on mutually confronting the dynamics of changes between the values of the built-up area and of other categories (mainly agricultural areas).

Similarly to the previous results of Šveda and Vigašová (2009) we can equally assume that the rise in built-up areas occurs at the expense of farmland.

2. Study area designation

The essence of suburbanization as one of the most significant processes impacting the transformations of the suburban landscape consists in the deconcentration within the region which occurs inside a network of various relations between the city and its hinterland. If we therefore wish to follow the suburbanization processes we need to centre our attention on a region the construction of which reflects complex spatial and functional relations between the city and its hinterland. In Slovakia this condition is met by the Functional Urban Regions designed by Bezák (Bezák, 2000) derived from the concept of daily urban systems. Each FUR represents an internally cohesive and integrated unit in which a decisive majority of the daily contacts of the inhabitants is realized.

In the paper we analyze the ongoing processes of suburbanization within the aforesaid Functional Urban Regions of Banská Bystrica and Zvolen. The monitored area of Banská Bystrica FUR includes 42 municipalities which fall exclusively under the district of Banská Bystrica. FUR Zvolen consists of 45 municipalities, out of these 26 belong to the Zvolen district, 15 to the Detva district and four to the Krupina district (Fig. 1).

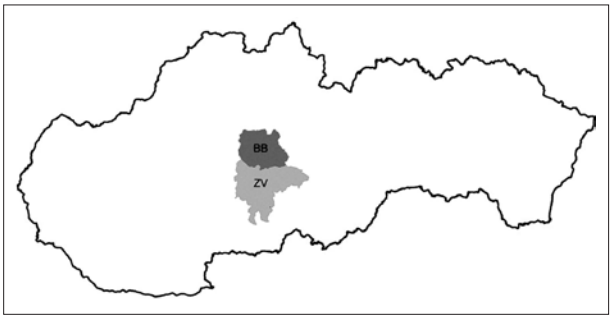

Fig. 1: Delimitation of FUR Banská Bystrica and FUR Zvolen within Slovakia

3. Characterization of the study areas

Both FURs are located in the area of Slovenské stredohorie Mts. projecting into the region of the Fatra Mts. and Tatra Mts. in the north and descending into the Lučenec-Košice Depression in the south. The cities of Banská Bystrica and Zvolen are expanding within the space delimited by the Zvolen Basin surrounded by a series of volcanic mountain ranges. Suitable physical-geographical conditions enabled the formation of important concentration centres (Banská Bystrica and Zvolen) in this area. These are significant population centres of human potential, services and other activities of Central Slovakia (Tab. 1) balancing the attractiveness of the existing centres of Western (Bratislava) and Eastern Slovakia (Košice) (Landscape Atlas, 2002).

The attractiveness of this region is also stressed by soil conditions and a developed transport network. In terms of soil types along the Hron R. Fluvisols are predominant, while further away from the riverbed of the principal river axis Cambisols prevail, which the WRB classification system characterizes as intensively exploited soils by farming of a significant productive potential. Another quite frequently represented soil type particularly in FUR Zvolen are Luvisols[1], equally

[1] Thanks to their qualities Cambisols, Luvisols, Fluvisols, Mollic Fluvisols and Mollic Gleysols are exploited as arable land.

FUR	No. of municipalities	No. of inhabitants	Surface area in km^2	EAP	of which	EAP in the primary sector	EAP in the secondary sector	EAP in the tertiary sector
Banská Bystrica	42	111,984	808	59,256		1,648	10,405	27,425
Zvolen	45	103,026	1,262	53,090		3,232	10,753	21,470

Tab. 1: Characterization of FUR Banská Bystrica and FUR Zvolen (EAP – Economically active people)
Source: Urban and Municipal Statistics, 2001; own calculations

distinguished by good fertility and a high degree of agricultural use. Mollic Fluvisols and Mollic Gleysols are among the most fertile soils – also in terms of the entire Slovak territory (IUSS Working Group WRB, 2006; Landscape atlas, 2002; Sobocká, 2000) – despite their low surface area representation in the surveyed area.

It results from the aforesaid information that the rural and urban territories of the municipalities at hand dispose of soils exploited by farming (arable land, permanent grasslands) or with a potential for farming.

At the core of the region's transport system are road and rail transports. The monitored area is intersected by international traffic routes E77 (Warsaw – Cracow – Budapest) and E571. The following arterial roads are important with regard to the regional development of the area: R1, connecting Banská Bystrica to Zvolen, I/59 in the direction of Donovaly, I/66 in the direction of Krupina and Brezno and I/50 leading towards Detva. All of these roads are an important development axis of this region concentrating important activities of the inhabitants.

The backbone of transport by rail is constituted by railroads of national (and international) significance, such as the southern major railway line (Leopoldov/Nové Zámky – Kozárovce – Zvolen – Lučenec – Košice), the railway line Zvolen – Kremnica/Banská Bystrica – Vrútky, railway line Zvolen – Banská Bystrica – Margecany and Zvolen – Šahy – Štúrovo. The transport system is complemented by the international airport Sliač (Plan of Transport Services of the Banská Bystrica Self-Governing Region, 2008).

4. Methodology

The Aggregate Areas of Land Types (AALT) database records basic land use classified in 11 categories: arable land, vineyards, hop-fields, gardens, orchards, permanent grassland (hereinafter referred to as PG, falling under farmland), forest land, bodies of water, built-up and other areas (for more details see Feranec, 2008). Its advantage lies in its simple structure (municipality – district – region) and annual updates (summaries are published as of January 1st of each year specifying the condition of land use types for the previous year). The interpretation of the AALT database data requires that some of their specific features are taken into account.

According to Feranec (2008) and Bičík and Kupková (2006) markedly significant differences may exist between the legal state and the actual land use. The national statistics in particular keeps track of land use changes with a lag of time, a fact to bear in mind when interpreting the processes underway in the land use structure.

Another attribute of the AALT database is that it essentially evaluates the decreases and increases in particular categories of territorial units (cadastral areas) and does not keep track of any potential movement inside the specific area meaning that a change in the location of the given category is possible without a change in its extent. Forest land may not actually be covered by forest and arable land does not need to be used exclusively for farming purposes and may shortly turn into fallow grassland. Before 1989, these differences were negligible but the changes dynamics speeded up during the transformation period. These changes are nevertheless relevant only at the micro-regional scale and they can be omitted at the regional scale[2].

The research of land use dynamics based on the AALT database therefore offers the possibility of making assessment applicable at the regional and supraregional levels.

[2] In Slovakia Oťaheľ and Feranec (2006) and Feranec and Oťaheľ (2009) deal with land use changes based on satellite images (micro-regional approach). One of the many projects in the field in which also the Slovak Republic participates through the mediation of the Geographical Institute of the Slovak Academy of Sciences is connected with the European project CORINE Land Cover 2006 (CLC2006). The aim of this project is among other things the identification and evaluation of land cover changes in Europe using satellite images from the period of 2000 to 2006. The results of this project will be used in the Global Monitoring for Environment and Security (GMES) programme, which forms part of the global monitoring system. GMES programme is one of the framework programmes supported within the 7th RP EU.

The AALT database enables using various approaches and data processing. Since the authors wished to determine the suburbanization processes, they opted for the following three indicators:

1. Change index of land use is a number evaluating the proportion of areas which witnessed a change in the basic categories of particular municipalities between two specific dates (Bičík, Kupková, 2006). This indicator gives us a basic idea of the intensity of changes; it is however advisable to supplement it with other indicators that more adequately address the actual land use changes. The fact that the indicator includes changes in all categories renders it incapable of clarifying their concrete nature (its higher values could be caused by an increase in the built-up area as a result of a construction of logistics premises as well as of a conversion of arable land into PG due to changes in the production structure of a farm cooperative). The mathematical expression of the indicator is as follows:

$$IZ_{(a-b)} = \frac{\sum_{i=1}^{n} |r_{ib} - r_{ia}|}{2c} \times 100\ [\%]$$

where $IZ_{(a-b)}$ is an index of change for an a – b period; n is a number (11) of land use categories (according to the methodology of classification of the Geodesy, Cartography and Mapping Authority of the Slovak Republic from 1996), r_{ia} is the surface area of the i-category at the beginning of the period and r_{ib} at the end of the period and c is the overall surface area of the territorial unit at hand[3].

2. The second applied indicator was a percentage of increase/decrease in the particular land use categories. The indicator stating the change in the built-up area category had the highest information capability for the aims of the paper. Therefore only results for this indicator are shown. We used the following formula for the calculation:

$$ZP_{k(a-b)} = \left(\left(\frac{r_{ib} \div c_{ib}}{r_{ia} \div c_{ia}} \right) \times 100 \right) - 100\ [\%]$$

where $ZP_{k(a-b)}$ is a change (increase or decrease) to the surface area of the specific land use category, r_{ia} is the surface area of the property type at the beginning and r_{ib} at the end of the given time period, c_{ia} is the total surface area of the surveyed territorial unit at the beginning and c_{ib} at the end of the specific time period[4].

3. The dominant processes in the land use method based on the method of principal landscape processes represents a good way of summarizing the changes to the structure of property types, municipalities in particular. This method was first introduced and applied in landscape assessment by Slovenian geographers (Gabrovec et al., 2001; Gabrovec, Petek, 2002) in their research in Slovenia and by Bičík and Kupková (2006) in the Prague urban region. We adapted this method to the input data from the AALT database and applied it in the area of the selected FURs to evaluate the major changes occurring in individual municipalities. This method is based on simplifying the structure of the property types into five categories, in our case: arable land + vineyards + hop-fields + gardens + orchards; permanent grassland; forest land; bodies of water; built-up + other areas[5]. Within this structure positive and negative values of changes in the surface area of the aforesaid categories are determined between two specified points in time. The share of the highest positive value in the total positive changes is calculated and if it exceeds 75%, we refer to a strong process of intensification of farming, grassing, afforestation, expansion of bodies of water or urbanization; if it is within the range of 50–74.9%, it is considered as medium and between 25–49.9% as moderate intensification.

While using this method, one however needs bear in mind the limitations entailed in calculations with absolute values of changes to the surface area privileging the AALT categories characterized by large surface area. Hence a minor change in the category with a large absolute surface area can eventually assert itself at the expense of a significant change in a category of smaller acreage.

5. Assessment of results of the AALT for FUR Banská Bystrica and FUR Zvolen

When evaluating changes according to the change index it can be stated (Fig. 2) that the deepest changes (to any category) in FUR Banská Bystrica between 2000 and 2008 were registered by municipalities located in the south-western, north-eastern and

[3] Change index can have positive or negative values. The higher the positive values, the more intensive dynamics of changes occur in the municipality.

[4] Values of this indicator can be either positive or negative. Negative values indicate a decrease in the built-up areas. Positive values conversely indicate an increase.

[5] Including built-up areas and other areas into one category may seem controversial. In some municipalities the changes occurring in these two categories were mutually contrary so their inclusion in one category caused their elimination.

western parts of the area and inside the administrative borders of Banská Bystrica. Municipalities located in the south-western part of the FUR form part of the contact zone, i.e. the zone which is directly contiguous to both FURs. This state is to a certain degree related to the course of development channelled towards the space between Banská Bystrica and Zvolen – i.e. into the concentration areas of the Zvolen Basin which sees a great influx of people from both towns as well as from their environs due to the suburbanization processes.

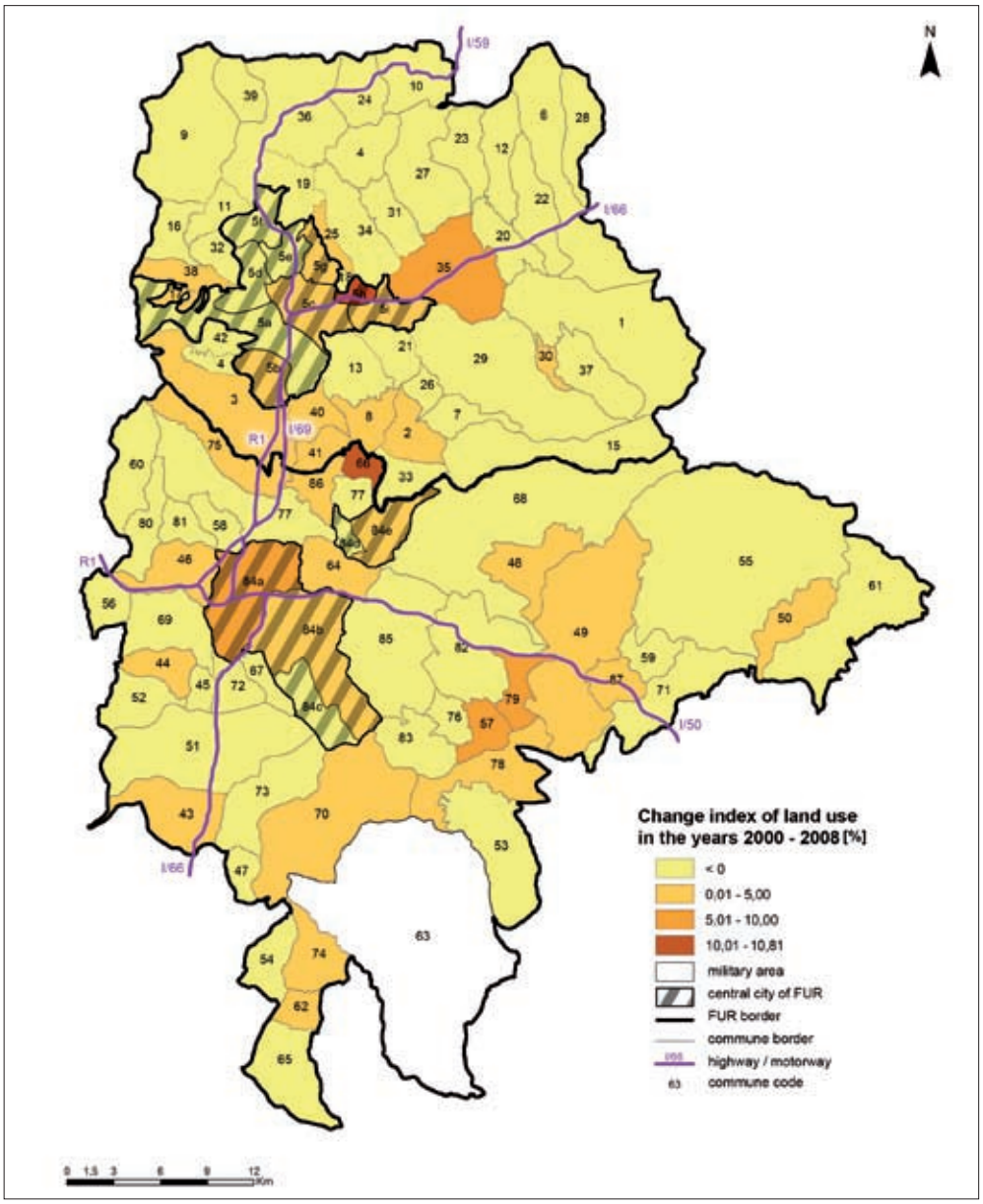

Fig. 2: Change index of land use in the FURs Banská Bystrica and Zvolen in the years 2000–2008
Source: Database of the Aggregate Areas of Land Types 2000–2008

FUR Banská Bystrica: *1 Ľubietová 2 Čerín 3 Badín 4 Baláže 5 Banská Bystrica k.ú. 5a Radvaň 5b Kremnička 5c Banská Bystrica 5d Podlavice 5e Kostiviarska 5f Uľanka 5g Sásová 5h Senica 5i Šálková 6 Brusno 7 Dúbravica 8 Dolná Mičiná 9 Dolný Harmanec 10 Donovaly 11 Harmanec 12 Hiadeľ 13 Horná Mičiná 14 Horné Pršany 15 Hrochoť 16 Kordíky 17 Králiky 18 Kynceľová 19 Španie Dolina 20 Lučatín 21 Môlča 22 Medzibrod 23 Moštenica 24 Motyčky 25 Nemce 26 Oravce 27 Podkonice 28 Pohronský Bukovec 29 Poniky 30 Povrazník 31 Priechod 32 Riečka 33 Sebedín-Bečov 34 Selce 35 Slovenská Ľupča 36 Staré Hory 37 Strelníky 38 Tajov 39 Turecká 40 Vlkanová 41 Hronsek 42 Malachov*

FUR Zvolen*: 43 Babiná 44 Bacúrov 45 Breziny 46 Budča 47 Bzovská Lehôtka 48 Dúbravy 49 Detva 50 Detvianska Huta 51 Dobrá Niva 52 Dubové 53 Horný Tisovník 54 Horné Mladonice 55 Hriňová 56 Hronská Breznica 57 Klokoč 58 Kováčová 59 Korytárky 60 Železná Breznica 61 Látky 62 Lackov 63 Lešť 64 Lieskovec 65 Litava 66 Lukavica 67 Michalková 68 Očová 69 Ostrá Lúka 70 Pliešovce 71 Podkriváň 72 Podzámčok 73 Sása 74 Senohrad 75 Sielnica 76 Slatinské Lazy 77 Sliač 78 Stará Huta 79 Stožok 80 Tŕnie 81 Turová 82 Vígľaš 83 Vígľašská Huta 84 Zvolen k.ú 84a Zvolen 84b Môťová 84c Kráľová 84d Lukové 84e Zolná 85 Zvolenská Slatina 86 Veľká Lúka 87 Kriváň*

Thanks to good traffic connection between both locations (R1 expressway and the railroad) increased construction of shopping and large administrative complexes started to occur in the interurban area in the late 1990s.

Municipalities located in the northern and north-eastern parts of FUR Banská Bystrica were not marked by significant changes to the individual categories and their change indexes consequently range only between 0–1%.

In FUR Zvolen a fairly more mosaic-structured nature of changes was observed. The most notable transformations occurred in municipalities located in the northern, southern and south-eastern parts of the FUR and in the northern section of the Zvolen urban area. Municipalities situated to the north line the aforesaid contact zone between the FURs and the ones situated to the south copy the development course of FUR Zvolen towards the municipalities of FUR Krupina. A standalone group of municipalities distinguished by the most notable change index is located around Detva which is the second core of development of FUR Zvolen (Fig. 2).

Indicator of increase or decrease of the built-up area (Fig. 3) suggests that the highest registered increase in built-up areas again took place prevailingly in the south-eastern, western and eastern parts of FUR Banská Bystrica as well as in its urban area. These are the municipalities situated in the

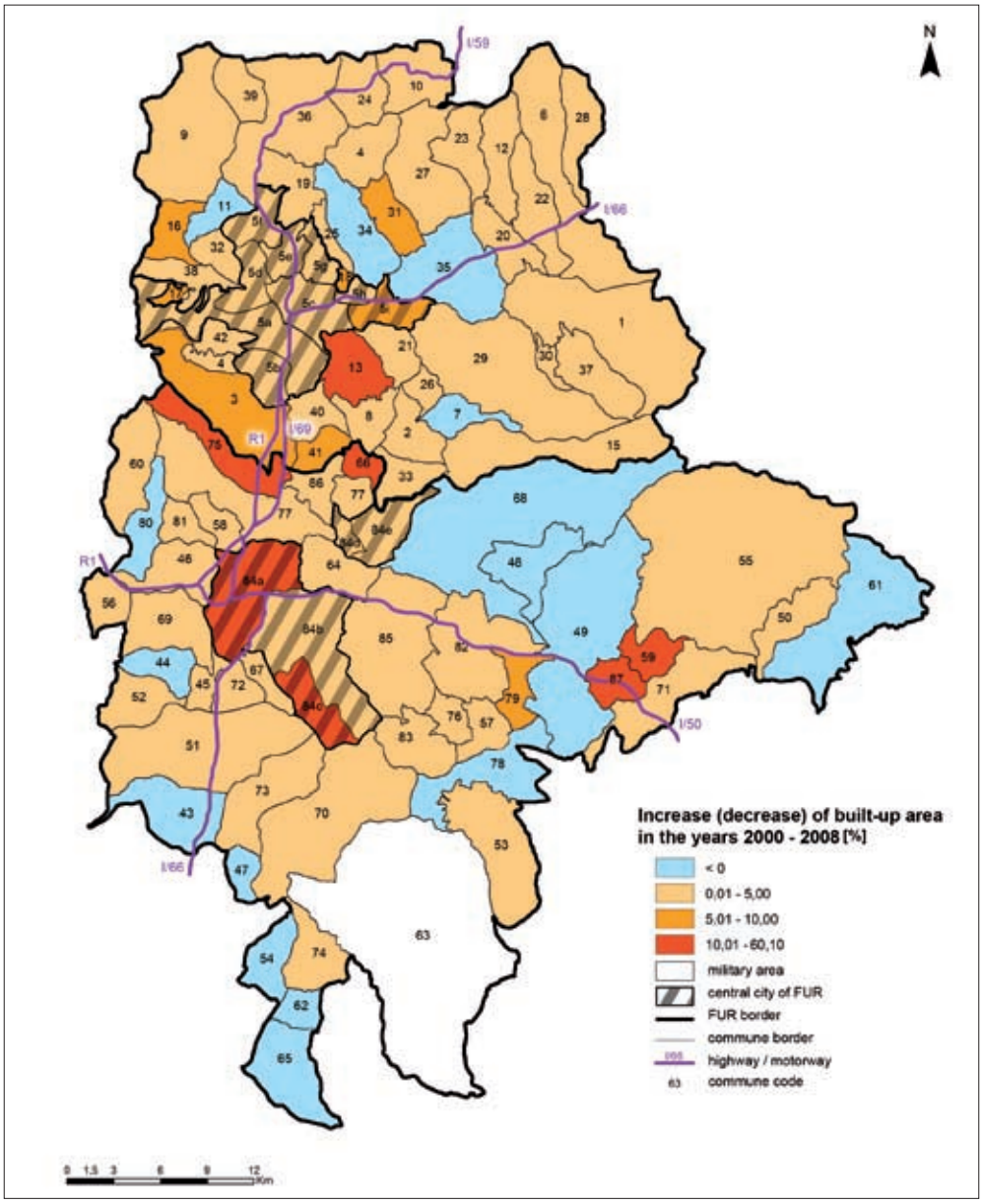

Fig. 3: Increase/decrease in the built-up area of the FURs Banská Bystrica and Zvolen in the years 2000–2008
Source: Database of the Aggregate Areas of Land Types 2000–2008

immediate hinterland of Banská Bystrica along the main transport routes in the Zvolen Basin where full-fledged suburbanization becomes manifest, not only in the form of residential but also commercial construction (shopping and administrative premises). The municipalities fulfill chiefly the residential function, whereas Banská Bystrica is the principal centre of commuting for work.

In each of these areas marked by an increase in built-up areas a decrease in farm (mainly arable) and forest lands was observed. The decrease within this category occurred chiefly in locations characterized by an increase in the built-up area which leads us to the conclusion that the built-up area grew in size at the expense of land valuable to farming.

A decrease in built-up area was mainly observed in the north-eastern part of the FUR. Despite its fast-growing Slovenská Ľupča municipality it was marked by a fall in the size of built-up areas which could have been due to this category's re-classification into the other areas category.

Rise in built-up areas in FUR Zvolen occurred particularly in municipalities belonging to the contact zone with FUR Banská Bystrica, in the urban area of Zvolen and partly in the surroundings of the second core area of Detva. In contrast with FUR Banská Bystrica it has a predominant share of municipalities marked by a decrease in the built-up area. Intense downturn took place in the eastern part of FUR Zvolen. Construction "boom" in these municipalities does not suffer stagnation but just as in the case of FUR Banská Bystrica municipalities the drop in built-up areas must be probably attributed to reclassification into the other areas category.

Figure 4 which shows the dominant processes in FURs Banská Bystrica and Zvolen is to a certain degree compatible with Fig. 2 in terms of the spatial organization of principal changes. The most significant processes occur in municipalities lying in the southern and south-eastern, western and eastern sections of FUR Banská Bystrica and in the urban area of Banská Bystrica (Figs. 5 and 6 – see cover p. 2). Medium urbanization occurs in the municipalities of Králiky and Badín which presently rank among areas of vigorous construction of family houses and development on open spaces after the arrival of new residents from the town and its closest environs. This trend is associated with the process of suburbanization and especially with its residential form. Apart from this, Badín occupies a position in the environment of a high competition between Banská Bystrica and Zvolen.

In the municipalities of Horná Mičiná, Hronsek, Čerín, Čačín and Tajov the biggest changes occurred in the grassing category (medium and strong grassing). This phenomenon, like construction, takes place at the expense of arable land and chiefly in these parts of the fertile Zvolen Basin it leads to soil degradation and decline. Large areas of arable land or farmland lie fallow or serve only as pastures since growing crops on them is not worthwhile and they soon become classified as PG.

Strong afforestation occurs in Slovenská Ľupča municipality which can be explained by the fact that the bulk of the municipal cadastre consists of forest the expansion of which has been evident recently. The same applies for the municipality of Nemce, although it is characterized by a strong intensification of farming. This municipality has preserved its agricultural nature over numerous years and it is therefore not necessary to search for deeper explanations of the current situation.

Strong urbanization in FUR Zvolen takes place only in three municipalities – Kriváň, Stožok and Lackov – which attract the main courses of development due to their vicinity to the administrative borders of Detva and Krupina. The municipality of Kriváň also registered high values of built-up areas. In other municipalities the processes of grassing (Horné Mladonice, Litava, Detva, Dúbravica, Klokoč, Slatinské Lazy, Budča, Lieskovec and Veľká Lúka) and processes of afforestation were prevalent (Stará Huta, Pliešovce, Babiná and Lukavica).

Processes of grassing occur in all Zvolen town districts which can be due to large plots of arable land lying fallow and their subsequent reclassification to PG.

6. Conclusion

Suburbanization is among the phenomena that has left marks on the hinterland of the majority of late 20th century Slovak towns. These are not merely processes transforming the internal structure of post-socialist cities (gentrification, commercialization, segregation, etc.) but also external processes, one of which is unambiguously also suburbanization (Sýkora, 2003; Matlovič, 1998). Its manifestations are diverse but it most frequently concerns intense growth of residential housing and of the number of commercial activities centres in the suburban zone of the cities (Bičík, Kupková, 2006; Ouředníček, 2003).

The Aggregate Areas of Land Types database at the municipal level provides a good picture of the suburbanization progress based on the changes to

land use (morphological approach) for the surveyed time period (Šveda, Vigašová, 2009). This research analyzed the changes in spatial structure in the FURs Banská Bystrica and Zvolen for which we opted with regards to our main aim at applying three indicators characterized in the Methodology.

If follows out from the results that during the observation of the three indicators between 2000 and 2008 the processes developed with different intensities. The most notable changes took place in the categories built-up areas (increase) and farmland (decrease) in the municipalities of the "contact zone" along the border between both FURs due to mutual competition of both towns and the pressure imposed on this zone. On the other hand it is an area of the most immediate effects of both locations characterized by an effort of mutual functional and spatial interconnection. Land use changes – the increase in the category of built-up area – occurred in the municipalities of the urban areas hinterland of Banská Bystrica, Zvolen and partly Detva. This is stressed by the fact that these municipalities have closest ties to the aforementioned towns; with regards to suburbanization it is therefore an area subject to strong urban influence.

The growth of built-up areas in these locations of both FURs is predetermined also by the relief form: the terraces of Hron R. and the slopes of the surrounding

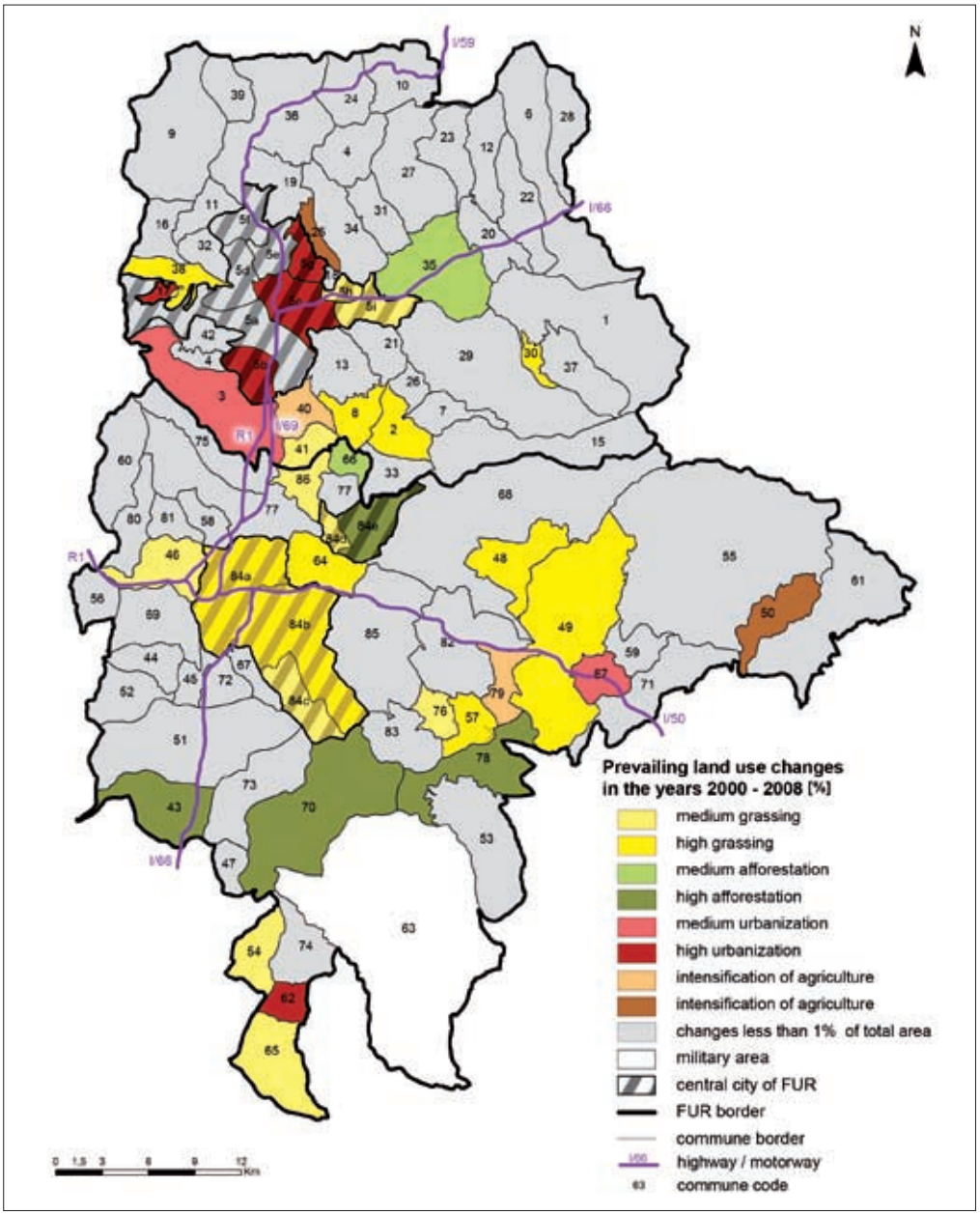

Fig. 4: Prevailing land use changes of the FURs Banská Bystrica and Zvolen in the years 2000–2008
Source: Database of the Aggregate Areas of Land Types 2000–2008

mountain ranges descending into the Zvolen Basin offer suitable conditions for settlements and the expansion thereof. Another important factor of the built-up area development of the region is a good transport network connecting mainly the aforesaid towns. The residential and commercial built-up areas copy these traffic routes to a great degree.

It results from the ascertained increase in the category of built-up areas at the expense of farmland (see above) that the development on farmland brings about a loss of its ecological functions accompanied by an increased prominence of the socio-economical functions. The coverage of soils by impermeable materials results in changes to their properties, its insulation from other elements of the ecosystem and overall degradation.

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Authors' addresses:

Mgr. Daniela VIGAŠOVÁ, e-mail: *daniela.vigasova@gmail.com*
Mgr. Martin ŠVEDA, e-mail: *mato.sveda@gmail.com*
Comenius University in Bratislava, Faculty of Natural Sciences
Department of Regional Geography and Landscape Planning and Protection
Mlynská dolina, 842 15 Bratislava 4, Slovakia

Mgr. Ľubica PAPAJOVÁ-MAJESKÁ, e-mail: *lubica.papajova@fns.uniba.sk*
Comenius University in Bratislava, Faculty of Natural Sciences, Department of Lanscape
Mlynská dolina, 842 15 Bratislava 4, Slovakia

Mgr. Lucia KRÍŽOVÁ, e-mail: *krizova@fns.uniba.sk*
Comenius University in Bratislava, Faculty of Natural Sciences, Department of Soil Science
Mlynská dolina, 842 15 Bratislava 4, Slovakia

SPATIAL ORGANISATION: DEVELOPMENT, STRUCTURE AND APPROXIMATION OF GEOGRAPHICAL SYSTEMS

Pavel KLAPKA, Bohumil FRANTÁL, Marián HALÁS, Josef KUNC

Abstract

Various issues concerning spatial organisation as a theoretical construct are discussed in this paper. Some basics of the theoretical background and a literature review on the subject matter, not aspiring to completeness, are provided. Three thematically-related research projects, which are currently underway in conjunction with several Czech academic and scientific institutions, are then presented. These projects are concerned with issues of a spatial organisation of geographical systems from the human geographical point of view. Each project is then discussed with respect to both theoretical-methodological bases, as well as presentation of some of the research results.

Shrnutí

Prostorová organizace: vývoj, struktura a aproximace geografických systémů

Příspěvek se zabývá problematikou prostorové organizace. Nejprve uvádíme základní a úvodní teoretické pozadí a rešerši literatury týkající se tématu, bez aspirace na úplnost, posléze navazujeme představením třech tématicky spojených výzkumných projektů zabývajících se problematikou prostorové organizace geografických systémů z humánně geografického pohledu, které jsou aktuálně řešeny v rámci spolupráce několika českých akademických a výzkumných pracovišť. Každému projektu je věnována jako teoreticko-metodologická pasáž tak představení některých výsledků výzkumu.

1. Introduction

Organisation of the environment of an individual and a society objectively exists since the dawn of the humankind. Only historically recently has this originally unconsciously reflected reality become a research issue, when, regarding the research subject and object, a key role is being played by geography. At first, theoretical and practical issues of the spatial organisation of the settlement system were studied in relation to agricultural production (von Thünen, 1826), industrial locations and resource distributions (Weber, 1909) or commerce and services (Reilly, 1931; Christaller, 1933). Eventually the phenomenon of the spatial organisation freed itself from the primarily economic platform and moved towards the social and cultural issues (e.g. Hägerstrand, 1953). A spatial dimension is thus comprised also in the human behaviour which changes faster than classic economic processes.

The Czech Republic has been going through a crucial social-economic transformation since 1990, which is deeply reflected in the change of spatial organisation and human behaviour, when several generations have completely changed their cultural and social customs. Among the realms having been influenced most we rank services, retail and leisure, which are primarily related to daily activities of the population of a nodal region. These changes are of the great interest for geographers since they also affect delineation of regions and their inner structure.

It was by the end of 2008 when geographers from several institutions joined to form an informal research group tackling from different points of view questions of the spatial organisation of geographical systems, their development, structure and approximation.

Since 2009, the research of the spatial organisation of the geographical environment has been supported by three scientific grant projects. They are handled by the Department of Geography, Palacký University in Olomouc; Department of Regional Economics and Administration, Masaryk University in Brno; Department of Environmental Geography, Institute of Geonics, Academy of Sciences of the Czech Republic; Department of Geography and Regional Development, University of Ostrava; and Department of Geography, University of South Bohemia in České Budějovice.

The primary objective of this report is to introduce these thematically loosely related, but sufficiently distinct research projects in a following manner: first (section 3) some basic theory and methodology regarding each project is briefly presented, and second (section 4) some of the first results are put forward. The report should be taken as a communication to the professional public representing the recent work of our research group. As all three projects are in a way related under the heading of the spatial organisation, section 2 briefly hints at some features of the concepts, without any aspiration for completeness or construction of a new "theory". It just puts forward some of our opinions on the subject matter.

2. Spatial organisation: a concise theoretical discussion

The concept of the spatial organisation, which has been for decades one of the basic geographical research themes enabling both theoretical enquiry and practical applications, has not been in our opinion clearly defined so far. Neither is it obvious how to tackle the concept theoretically and methodologically. These facts are caused by the immense complexity of the concept, which can be roughly matched to the whole object and subject of human geography as a scientific discipline, and also by different geographical traditions across the world. The Anglo-Saxon authors understand the spatial organisation in several different ways, which, however, have a strong common basis in the relatively wide conception of the issue.

Especially two works by Haggett (1965) and Morrill (1974) that seem to be more focused on the topic have been more inspiring, particularly the latter. Haggett (1965) in his book on "Locational Analysis in Human Geography" introduces an interesting view of the organisation of a region, later refined by him in "Geography: a global synthesis" (Haggett, 2001). He sees five region-building or spatial structure factors: movements, networks, nodes, surfaces and diffusion stages. He also introduces a concept of hierarchies into his concept. Such an approach is more aimed at the subject in question.

In his book fittingly named "The Spatial Organization of Society" Morrill (1974) provides many inspirations and suggestions regarding location choice, emergence of hierarchies, spatial interactions through which he reaches a complex assessment of the spatial organisation of the regions. He puts primary stress on the population, its spatial distribution and movements, but he also emphasizes the role of such varied factors as the physical environment, land use and space use, distance, distribution of economic activities and wealth, cultural and political conditions, historical development of a territory etc. Owing to the period when the book was written, he, however, similarly as Haggett (1965), somewhat omits the role of human behaviour in the organisation of space and society assuming that everyone is in a fact Homo Oeconomicus obeying completely the principle of the maximum profit at the minimal effort. It is not that he does not mention the importance of human behaviour rather than he does not incorporate it to his proposed concepts and schemes. Morrill's most important conclusion however is that the spatial organisation is best described by the intensity and extent of land use and by the complex interactions pattern, which a location has within its environment.

In the Czech geography, the issue of the spatial organisation of the society (as it is mostly put forward) is concerned in the works of Prague geographers (Hampl, Gardavský, Kühnl, 1987; Gardavský, 1988; Hampl, 2005). Their concept is, however, quite different and in a way limited (not to be understood negatively!). It takes into account, in its applications, only the population, particularly its distribution (concentration, settlement system) and movements (labour and

service commuting). They claim that natural, political, cultural, economic or social conditions are well reflected in the population characteristics and traits, although in his theoretical study Gardavský (1988) sees the regional (i.e. geographical) organisation as a complex and at the same time substantial arrangement and concurrent action of all geographical phenomena and processes. Such an approach is relatively easy to apply on larger geographical scales, which is its greatest advantage; on the other hand we think that particularly the interpretation of the results can be simplified in a way not regarding other than population factors.

First we have to admit that both above-mentioned approaches to the concept of the geographical organisation have been a great inspiration for us each having its pros and cons. Thus we have attempted to define our own approach to the concept. In order to assess the geographical organisation we see three important factors:

1. population (its distribution and interactions),
2. land use (in its very broad meaning including the location of activities and networks of different types), and
3. environment (physical, economic, cultural, political and social), when the crucial importance is possessed by the first factor. We think that this could be a deliberate compromise between too narrow orientation to the population and too vast identification of the geographical organisation with human geography as the whole. We also feel the need for introducing a system of constraints of non-economic and non-quantitative nature in order to represent reality in a better way.

It is also to be noted in this place that the hierarchical level of researched territory matters to a great extent. If we are for instance dealing with the inner structure (and organisation) of a city (for instance sections 3.1 and 4.1 of this contribution) our effort is centred merely around people, while large regions (on mezzo or macro level) should be apart from their population studied also in terms of their land use and environment. Approaches should be also slightly different and stress put on the above-mentioned factors slightly shifted in case we study either dynamic or static geographical organisation of a territory.

Our proposal of more general theoretical approach towards the assessment of the geographical organisation still has to be cleared up, refined and more precisely stated. The first concrete outcome linked to one of the projects including some theory but mainly application is a bachelor thesis (Niedzwiedzová, 2010) on the historical development of the spatial organisation of the Nový Jičín region during the industrial revolution. This, however, needs to be viewed as a purely preliminary attempt to grasp the issue of the spatial organisation differently in a way hinted at in the above lines. Other studies still will have to be carried out and completed.

Detailed discussion of the spatial organisation concept in human geography is beyond the scope, theme and purpose of this contribution. The preceding passages have attempted to introduce also a partial or alternative view of the concept within the Czech geography that could contribute to its more complete comprehension. However, examples of research given below are just mere fragments in the mosaic of the complex issue of the geographical organisation of space.

3. Research in spatial organisation: selected specifics and methodology

The research primarily aims at an analysis of selected aspects of the spatial organisation at several hierarchical levels from microregional to national. Delineation of geographical regions and analysis of their inner structure is an underlying research task. Increased attention is paid to regional centres and to interactions with their hinterlands, both in spatial and temporal terms. The projects draw on quantitative and behavioural geographical methods and techniques and they are inspired by the significant social, economic and cultural transformations having occurred in the Czech Republic after 1990, and by their reflection in the spatial organisation of the geographical environment and the Czech society. All three projects are briefly characterised in the following chapters.

3.1 Spatial models of behaviour

The complexity of the spatial behaviour dynamics increases with individual motivations and interests, personal socio-demographic characteristics and cultural, political, economic and technological factors at a macro level. The principal objective of the Czech Science Foundation project (No. GA403/09/0885) "Spatial models of behaviour in a transforming urban environment: a time geographical approach" is to verify whether new phenomena appearing in the inner city structure after 1990 influence the spatio-temporal models of human behaviour and whether these models can contribute to municipal planning. The analysis pursues preferably the phenomena (i.e. "innovations" spreading in space and time) with a high leisure time potential, typically shopping malls or leisure centres, and population segments with a high amount of leisure time, high level of adaptability to the innovations and also relatively higher degree of social and economic dependence (students, women on maternity leave, and seniors).

The project is essentially based on the theoretical assumptions and methods of the time geographical school, particularly the use of space-time activity budgets recording daily trajectories of individuals and identifying their constraints. Phenomenological context and in-depth analyses of human behaviour are surveyed as well. The research is carried out in four cities (Brno, Ostrava, Olomouc and České Budějovice). As the Czech social sciences currently lack a complex research of the spatio-temporal human behaviour, we expect, apart from completing particular case studies, also a formulation of the generalised theoretical and methodological background that could be used in other similar researches.

The complex and relative character of the researched phenomena implies the use of trans-disciplinary and multi-paradigmatic approaches as related to the selection of research strategy. Both quantitative and qualitative methods of human geographical and sociological research are to be used to achieve partial research goals. The theoretical and methodological apparatus used in Time Geography (see e.g. Martensson, 1979; Friberg, 1993) provides tools for revealing space patterns of behaviour. The main data collection methods include various kinds of questionnaires in the form of time-space budgets, activity timetables, etc. The timetable method is frequently used in various sociological and marketing researches focused on studying everyday activities of individuals, their lifestyles, leisure time or shopping preferences, etc.; however these timetables recording time utilization and human activities in a specific time period (day, week, etc.) mostly leave out the space aspect, though. The time-space budget takes into account also spatial coordinates, i.e. specific localization of particular activity (Ira, 2001).

The research is focused on basic variables that structure the everyday activity schedule (according to Axhausen, 2002): (a) activity type, (b) activity location, (c) activity time, (d) activity time period, (e) size and composition of the social group where the activity proceeds, (f) realization costs (economic factor). The time-space budgets may also include the phenomenological context in the form of recording subjective feelings, evaluations and interpretations of partial activity significances from the acting persons' viewpoints, yielding qualitative data of greater informative value.

The specific population segments, whose behaviour is to be studied, should ideally feature a high level of adaptability to the innovation diffusion process and a relative abundance of leisure time. Students (with a fast adaptation to innovation at the primary stage of the diffusion process) comply with this condition in the pre-productive age. People in the post-productive age (they adapt to innovation during the later stages of the diffusion process, but much more carefully) are the second investigated segment. Families with children are the last investigated but a very strong segment, representing a rather wide population sample.

The acquired data will be converted into the Geographical Information System (GIS) environment for the analysis and visualization purposes. GIS was primarily designed for analyses, modelling and presentation of spatial data (mostly of static character) but it has been

recently enhanced with tools providing for a deeper investigation of changes in the acquired spatial data in time and their well-arranged presentation, mostly due to the 3D visualization/animation properties. These options provided GIS with a significant potential to become an important analytical tool for the research of time and space patterns of human activities (e.g. Kwan, 1999; Buliung; 2001), even though, as noted by Kwan (2004), their utilization in geography has been rather limited until recently (besides other things due to high financial and time costs spent on soft- and hardware, or rather on the computing operation time). Methods usable for the processing of time and space timetables include the following:

- Simple activity pattern in space-time, where each activity in the 3D model is plotted as a point with geographical coordinates x, y and z, describing the starting time of the activity and the duration of the activity is represented by line length from the start point along the z axis direction,
- Generation of the 3D activity density surface, where a three-dimensional surface, whose "height" represents the spatial concentration of the activity, is generated by means of the kernel estimation method from the point distribution of the activities in space with geographical coordinates x, y,
- Geovisualization of individual space-time paths, essentially representing the application of the original concept of the space-time aquarium by T. Hägerstrand (1970).

3.2 Daily urban systems

Daily urban systems as a special case of the functional regions are analysed under The Grant Agency of the Academy of Sciences of the CR project (No. IAA301670901) "Spatio-temporal organisation of daily urban systems: an analysis and assessment of selected processes". The term urban system, simply described as a set of interdependent urban places, was introduced by Berry (1964) as a part of his application of systems analysis and general system theory to the study of central city places. National territories are organized, according to proponents of the urban system approach, as a set of urban-centred regions – towns and cities plus their hinterlands – which together exhaust the land area and are articulated into a working system through networks along which goods, services, ideas, capital and labour flow. Economic functions are distributed in such a manner that each urban centre and its associated hinterland have a prescribed set of roles within the whole (according to Johnston et al., 2000).

In relation to Berry's theory from the middle 1960s, the concept of the urban region became generally known by the end of the decade. It was achieved mainly by pioneering works of B. L. J. Berry (1967, 1970, 1973) in America and P. Hall (e.g. 1974 or 1980 with D. Hay) in Europe. Urban region is defined as a spatially continuous area, which is relatively closed in terms of daily migrations of the population to work, education, services, recreation and social contacts. Such a type of a functional region is more accurately termed as a daily urban system, which was according to Berry (1967) or Bezák (1990, 2000) proposed by Greek urbanist C. A. Doxiadis in 1967. The term "migration", noted above, can be substituted in general terms by the word "interaction", which serves better the concept of a functional region and its special case of a daily urban system. In most cases, labour commuting is used for the delineation of such regions because of insufficient data on other types of inter-regional relations. Works of Czech geographers led by M. Hampl delineate functional regions in the Czech Republic by labour commuting (e.g. Hampl, Kühnl, 1967) or by a combination of labour commuting and the interaction models (Hampl, Ježek, Kühnl, 1978; Hampl, Gardavský, Kühnl, 1987; Hampl et al., 1996). Regional delineation by Maryáš and Řehák (1987) dwells on a questionnaire survey on service attraction. Hampl (2005) or Mulíček, Sýkora (2008) based their delineation of functional regions dominantly on the labour commuting using the 2001 census data. Mulíček, Sýkora (2008) defined this regionalization as the local labour systems. As to foreign works, the functional regions or the daily urban systems in different variations were delimited by labour commuting data for example in the UK (Ball, 1980), Finland (Hirvonen, 1982) or Poland (Korcelli, 1982). Despite some notions in literature (e.g. Bezák, 1990) that labour commuting reflect relatively well a spatial structure of inter-regional contacts, our intention is, however, an attempt to delineate selected daily urban systems on the basis of the service commuting.

Two presuppositions have to be taken into account in this sense:
- the interaction must be based on the daily basis, i.e. the interaction comes out from the daily cycle of a person or a population segment,
- the intensity of the interaction has to exceed a certain critical value (so called level of significance); this value differs according to theme and objectives of the research.

The project has two main intentions:
- To use an interaction based on the commuting for retail services in order to delineate daily urban systems; at this, the interaction is either real – resulting from several types of surveys, e.g. with local authorities (e.g. Szczyrba et al., 2005), in selected retail facilities (e.g. Wokoun, 1983), in all settlements within the research area (e.g. Maryáš, 1987), or modelled by using the spatial interaction models (e.g. Isard et al., 1998),
- To analyse the internal structure of these areas on the basis of daily and weekly cycles of individuals.

Such a pursuit of the internal structuring of a daily urban system has not been very frequent in geography but it has its internal logic since the time span (i.e. one day) is usual both in the studies delimiting daily urban systems and in many studies, especially time geographical, on daily activities of individuals. The full research is carried out in two urban regions organised by the cities of Brno and Olomouc. Expected research results could provide a general insight into the spatial expression and reflection of social and economic transformation processes that have shaped our country since the end of the 1980s and could make a contribution to the regional planning.

3.3 Quantitative and graphic geographical methods

The Grant Agency of the Academy of Sciences of the CR project (No. KJB300860901) *"Quantitative methods and synthesizing graphic methods in approximation, projection and modelling of geographical phenomena"* is concerned with more theoretical and methodological issues of the spatial organisation, though it provides examples of the application of selected methods. The project involves discussion and application of spatial interaction models and tackles also the question of the graphical expression of results. Methods leading to the fulfilment of the objective are diversified. They can be divided into two basic spheres – quantitative methods in the approximation, projection and modelling of geographical phenomena and synthesizing graphical methods in the approximation, projection and modelling of geographical phenomena. Partial objectives of the project, both methodological and of application character, include for instance regionalization of the Czech Republic and identification of nodal regions based on labour commuting and confrontation of this regionalization with the existing patterns of socio-economic geographical regionalization, application of spatial interaction models at a national level and their use in the geographical differentiation of space, assessment of the effect of borders as barriers and environmental linear components on the organisation of socio-geographical space in selected model regions, construction of synthetic graphical expression of the spatial organisation of model regions by adequate graphical tools, or verification of the possibilities of alternative definitions of masses and distances in the spatial interaction models and their calibrations.

The project has wide opportunities of practical use for planning and revision of partial components of the geographical organisation of the society (e.g. the correction and optimization of the administrative division, planning and optimization of communication network at a national and regional level etc.). Stress on the natural spatial interaction can contribute to more precise and effective proposals of strategies for regional development.

Primary use of quantitative methods in approximation, projection and modelling of geographical phenomena is usually related to the potential model, which is historically, conceptually and empirically connected with the gravitation model. This is also the very first spatial interaction model in geography. Introduction of mathematical models into geographical research, together with other analogies from other scientific disciplines, became a stimulus forming a base for the

development of gravitation theory and potential models in regional geography. The reason for introducing the gravitation and potential concepts lied in the need for an objective measure of the intensity of mutual spatial relations among geographical phenomena or areas.

Theoretical and methodological basis of the interaction potential model comprises primarily its mathematical expression, different forms of the model, conditions under which the model can be used, its limitations, possible deficiencies and problems connected with its use, ways of interpretation etc. This is discussed in the works of Isard (1960), Chojnicki (1966), Rich (1980), Tikunov (1985), Hlavička (1993) and others. The unfolding phase of theoretical and methodological basis of the interaction potential model is connected with the quantitative revolution; nowadays this type of research is a thing of the past and interaction models are not subject of research. These works are however helpful in gaining adequate theoretical and methodological background needed for the application of the interaction potential model.

Synthesizing graphical methods result in graphical models of spatial phenomena and processes. Graphical models are not demanding for mathematical and statistical data processing, however, they often reflect existing analyses of researched area. They are demanding as to the ability of seeking logical causes and coherences, detailed command of available information about the area and sound synthetic thinking and ability to express synthetically the most important information on selected segments of geographical space. This expression can be to a great extent schematic. In the generalised form we can divide graphical models of spatial phenomena and processes into the following categories: 1) graphical models with the representation of a spatial component (either individual or typological), and 2) graphical models without the representation of a spatial component.

4. Applications in spatial organisation

This chapter presents some of the first research results. The first example deals with the regional centre and its inner structure in terms of time geographical concepts, the second example is concerned with the functional regions, and the third one shows a proposal of the graphical expression of the geographical organisation of space. This part attempts to illustrate the width and variety of possible approaches to the assessment and research of the spatial organisation of a territory.

4.1 The city: stations and paths

The application of selected time geographical methods is illustrated in Figs. 1 and 2. Both examples present the city of Olomouc and daily movements (daily life) of the university students (53 of them filled the space-time activity budgets). Fig. 1 is concerned with a nature of spatial occurrences of students in the urban environment (Klapka, Roubalíková, 2010) in one of the crucial concepts of time geography: stations. In the time geographical concept, station is understood as any place where an individual spends a certain amount of time. Thus, in a daily path of an individual, stations possess a conspicuous trait reflecting on the fact that movements of individuals are not registered while staying there. The stations have temporal and spatial dynamics. It means that some stations disappear during a particular period, and that their concentration and spatial distribution depends on the character of the geographical environment.

Fig. 2 deals with another crucial time geographical concept: the path. A path can be conceived as daily (or seasonal or life) trajectory that comprises, unlike the stations, both temporal and spatial movements. Each path is defined in terms of the origin point and time, destination point and time, exact route between origin and destination points. Fig. 2 presents total path intensities during a day in the city of Olomouc based on the daily trajectories of university students regardless of the way of the movement (transport). The figure has a character of a graph where each portion limited by two vertices is considered as an edge. Each edge is then given a load according to the sum of single occurrences of the students along the edge during a day.

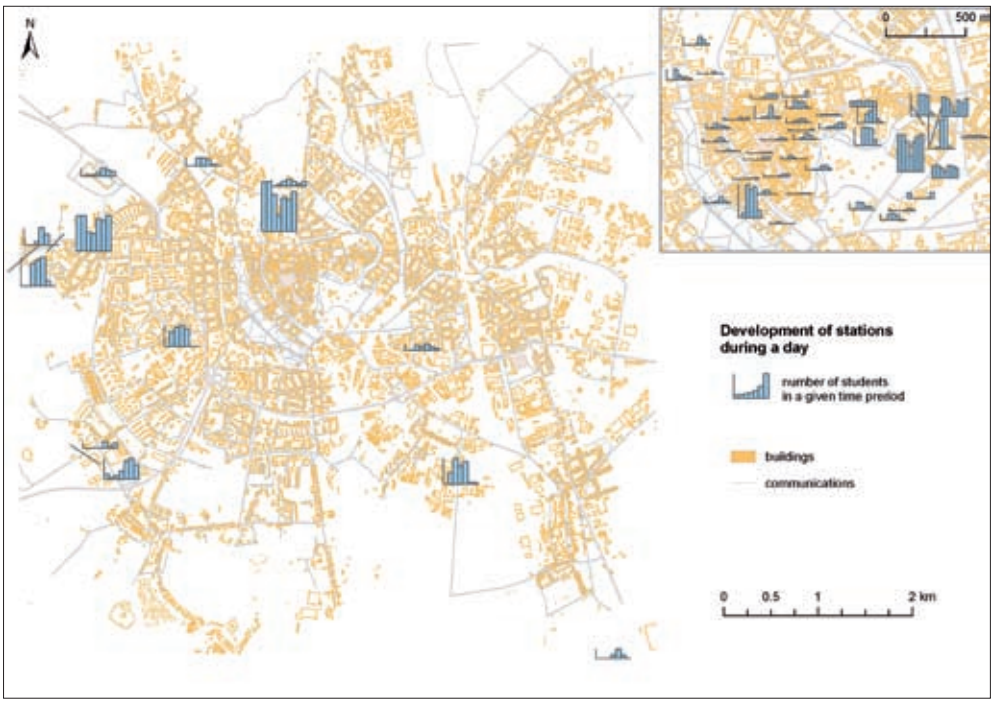

Fig. 1: Development of stations during a day – columns regard six defined time periods: from left to right 00:01–06:00, 06:01–08:00, 08:01–11:00, 11:01–13:00, 13:01–18:00, 18:01–24:00
Source: Klapka, Roubalíková, 2010

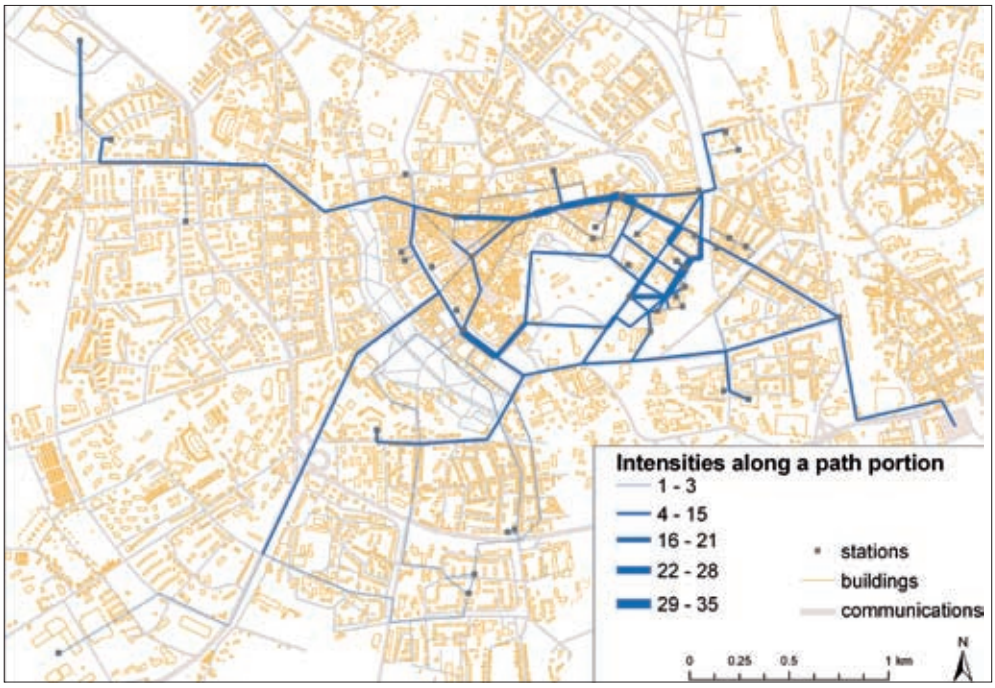

Fig. 2: Total paths intensities
Source: own design

4.2 The region: daily labour commuting

Delineation of regions according to daily labour commuting is one of the most applied methods used for the functional regionalization. In this chapter, we present the functional regionalization of South Moravia by nodal relations with a special attention to the functional region of Brno-City. Fig. 3 (see cover p. 3) puts forward a comparison of three methods delineating the functional region of Brno based on the same source data (labour commuting in the 2001 census), though providing different outcomes since the criteria were slightly different.

Halás et al. (2010) use the main flows of labour commuting to microregional centres as a crucial criterion. As the centre of commuting is considered a municipality that contains daily commuting from at least four more municipalities, which practically means that resulting micro-regions must include at least five municipalities. Hampl (2005) based his regional delineation dominantly on labour commuting and substituted school commuting (as an auxiliary criterion) for service attraction. Mulíček, Sýkora (2008 – Sýkora, Mulíček, 2009 respectively) defined local labour systems. The method of regions delimitation and their consequent image in the map is similar to Hampl (2005), small differences can be seen only in additional criteria resolving disputed cases of incompactness and unconnectedness of regions.

Fig. 4 (see cover p. 3) shows the functional region of South Moravia according to Halás et al. (2010). It explains basic differences among the method used by Halás et al. (2010) on the one hand and methods used by Hampl (2005), Mulíček, Sýkora (2008) and Sýkora, Mulíček (2009) on the other. The former considers as microregional centres also smaller municipalities mainly in the western part of the research territory while the latter assign their spheres of influence to the city of Brno. Thus, we have in Fig. 4 a chain of small microregions along a considerable portion of the border of Brno's sphere of influence (e.g. Tišnov, Moravský Krumlov, Hrušovany nad Jevišovkou, Hustopeče u Brna, Bučovice etc.).

4.3 The space: choremes

Graphical models (or choremes) are a strong tool for approximation and expression of the organisation of geographical space (Halás, Klapka, 2009). They are not demanding for mathematical and statistical data processing, but they ask for a high ability to search logical causes and consequences, for a synthetic thought and certain generalization. Their ambition is to define the most important spatial organisation forming processes and select them from the ones that are less fundamental. Their depiction can be to some extent schematic. Fig. 5 shows a matrix of 40 model situations, which is partly inspired by Brunet, Dolfus (1990).

5. Conclusions and implications

The article presents three examples of tackling the issue of geographical organisation from different viewpoints at different hierarchical levels, at different levels of abstraction, by different means of expression (time space budget survey, nodal daily relations, graphical methods). The already acquired results have in our opinion important theoretical and practical implications. The tested and improved theoretical and methodological framework of research projects represents a tool for studying social geographical activities, which may reveal phenomena, relationships and contexts of human everyday life that are not primary objects of interest of other socially oriented sciences. The time-space approach to the research of behaviour modes provides an apparatus for the systematic research of human activities, their arrangement in the context of life projects, determination of their sequences, time periods and various forms of constraints, including their social and geographical positioning in the context of the physical environment (Friberg, 1993; Ira, 2001, Steinführer et al., 2010). The analysis of daily urban systems and their inner structure provides important knowledge on the geographical organisation of the space, particularly the space that is related to human mobility. Graphical means of expression also contribute to theoretical apparatus of the geography as a science. Moreover, the hitherto acquired results are going to help us to formulate our own view of the issue of the geographical organisation in terms of theory and methodology.

The preliminary research results imply also a wide future applicable potential with a possible use as a part of municipal transportation planning, general community planning, urban development, delineation of administrative regions etc. As emphasized by many authors (e.g. Schönfelder and Axhausen, 2003; Schwanen et al., 2008 etc.), results of similar research studies represent foundations for potential strategies aimed at improving life quality of selected population groups threatened by social exclusion or in the territorial planning and place branding of locations/areas predisposed for social-spatial marginalization. In a wider context, the same can be applied in the core-hinterland system (i.e. the city and its functionally

linked surroundings) at a micro or mezzo regional levels. More generally, the research results could enhance the general understanding of the social consequences of social and economic transformation processes that have shaped our country since the beginning of the 1990s. The particular significance for the economic and social practical utilization consists in influencing the land-space planning in different kinds of environments (city, region, state).

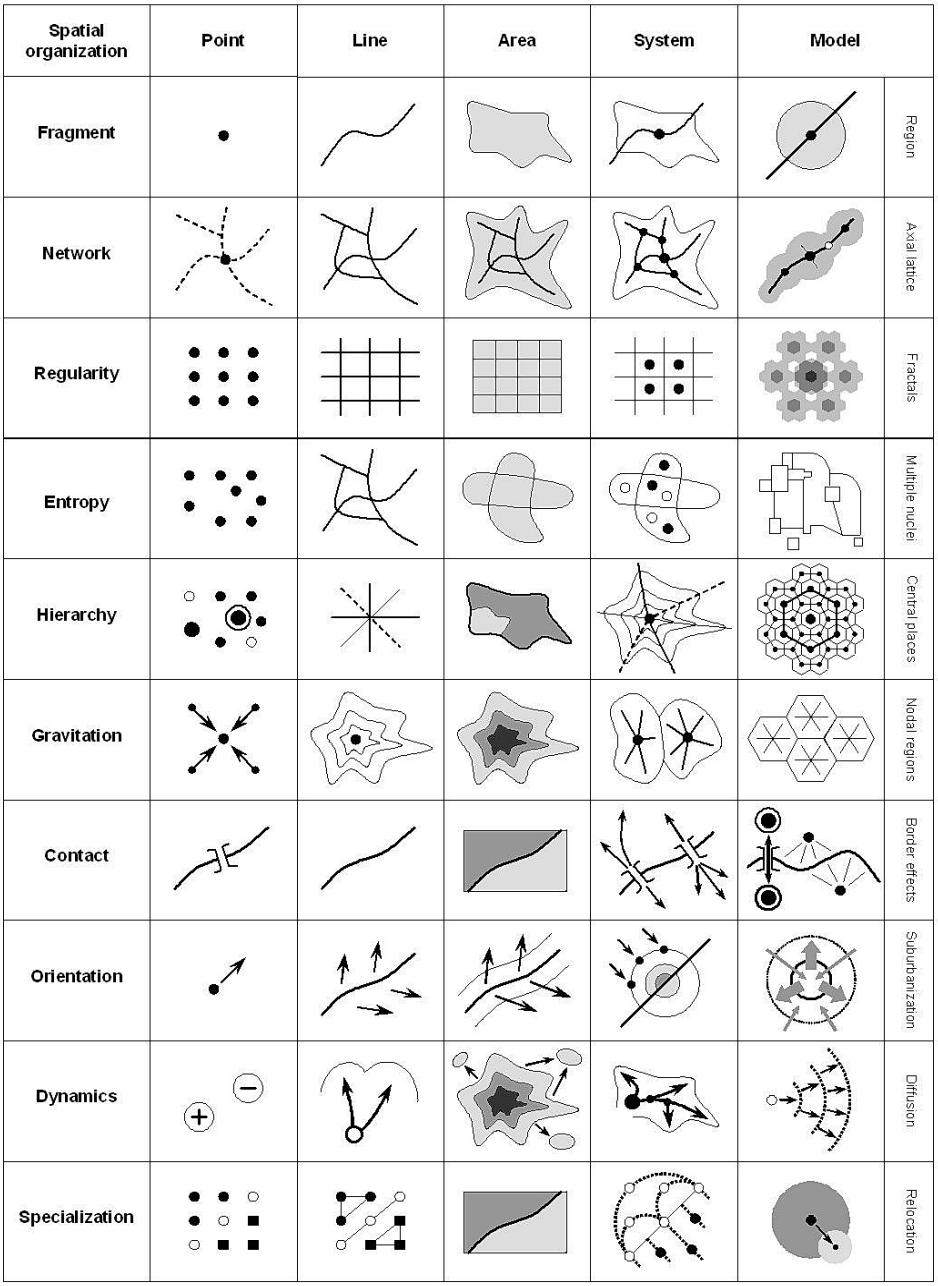

Fig. 5: Synthetic matrix of choremes
Source: Halás, Klapka, 2009

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Authors' addresses:

Mgr. Pavel KLAPKA, Ph.D., e-mail: *pavel.klapka@upol.cz*
Assoc. Prof. RNDr. Marián HALÁS, Ph.D., e-mail:*marian.halas@upol.cz*
Palacký University in Olomouc, Faculty of Science, Dept. of Geograhpy
třída 17. listopadu 12, 771 46 Olomouc, Czech Republic

RNDr. Bohumil FRANTÁL, e-mail: *frantal@geonika.cz*
Institute of Geonics, v. v. i., Branch Brno
Drobného 28, 602 00 Brno, Czech Republic

RNDr. Josef KUNC, Ph.D., e-mail: *kunc@econ.muni.cz*
Masaryk University in Brno, Faculty Economics and Administration
Department of Regional Economics and Administration
Lipová 41a, 603 00 Brno, Czech Republic

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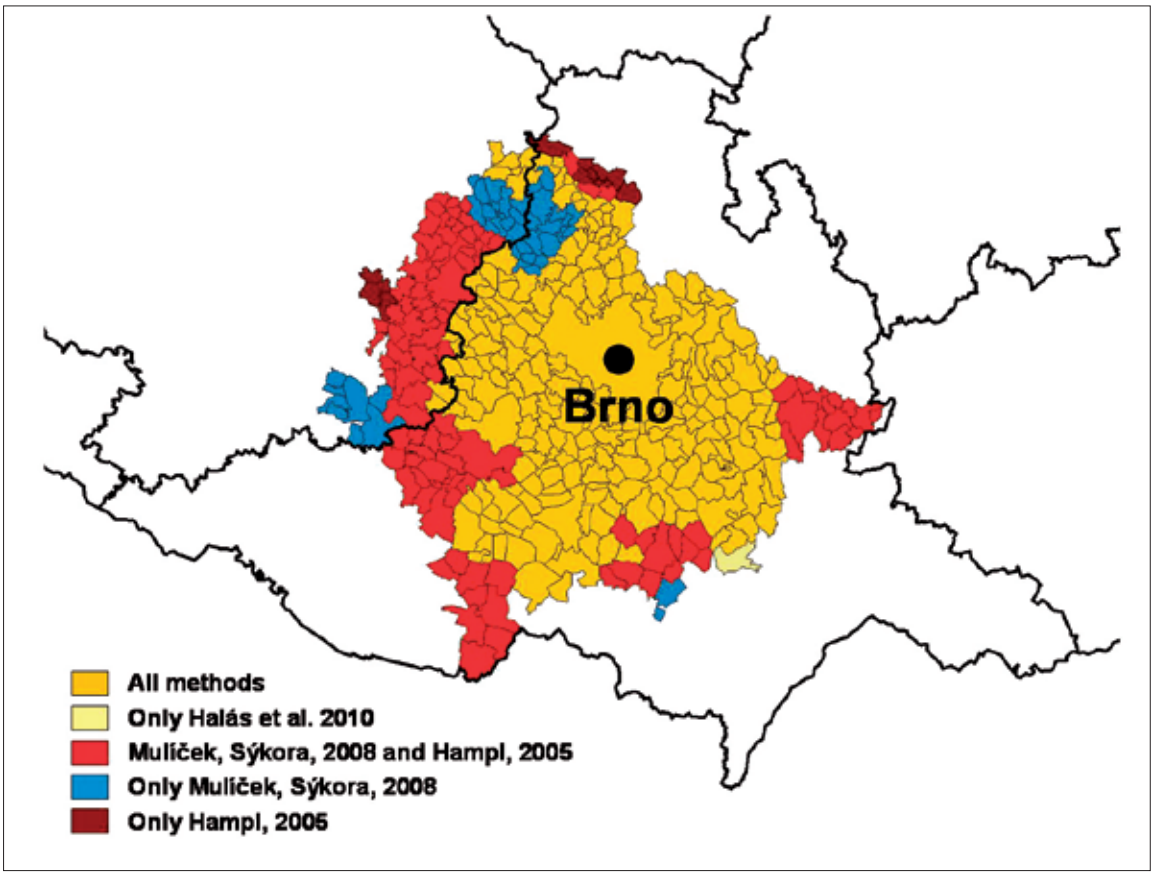

Fig. 3: Functional region of Brno: a comparison
Source: Halás et al., 2010; Hampl, 2005; Mulíček, Sýkora, 2008; Sýkora, Mulíček, 2009

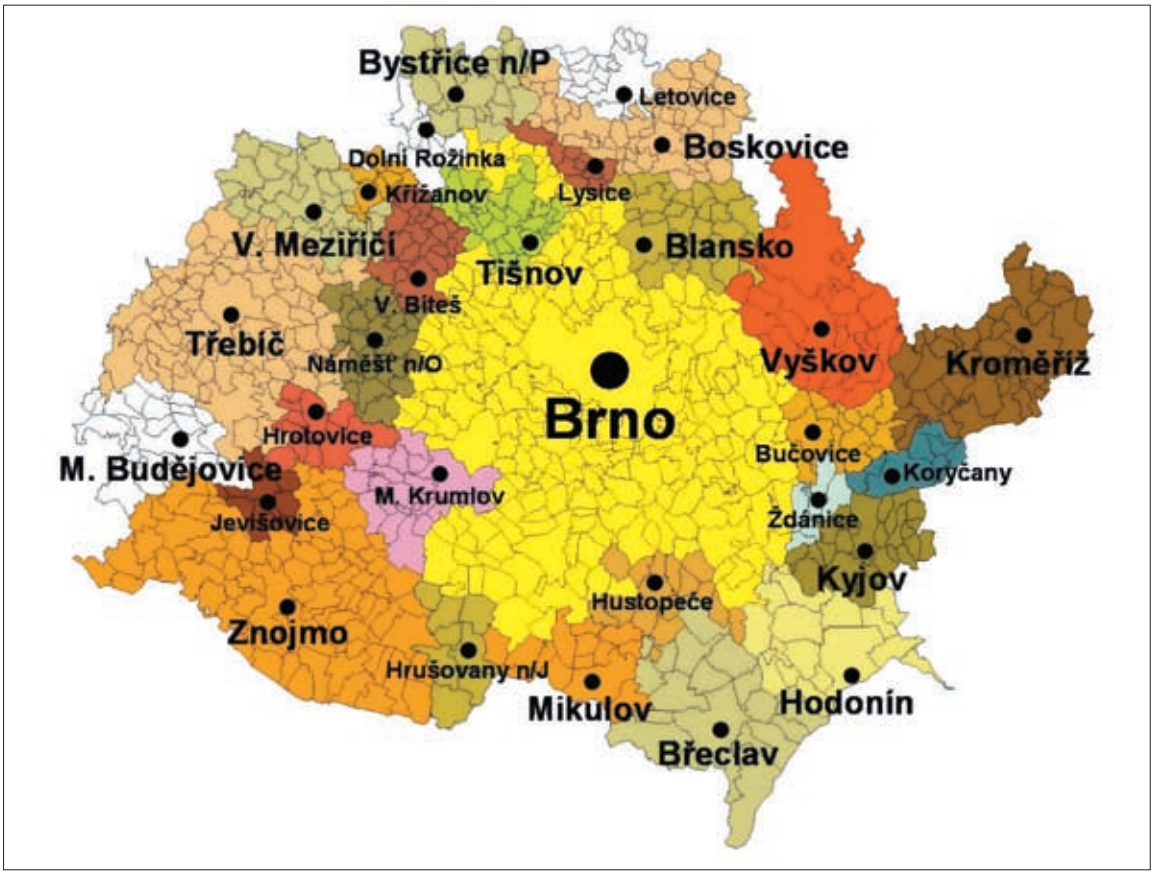

Fig. 4: Functional regions in South Moravia
Source: Halás et al., 2010

Illustrations related to the paper by P. Klapka, B. Frantál, M. Halás and J. V. Kunc

Fig. 3: Tump at the top of Mt Sýkoř with a spot-height of 701.7 m a.s.l. (Photo M. Havlíček)

Fig. 4: Frost-riven cliff in the Bíteš gneiss on the top of Mt. Sýkoř with abri at the foot (Photo M. Havlíček)

Illustrations related to the paper by J. Demek, M. Havlíček and P. Mackovčin