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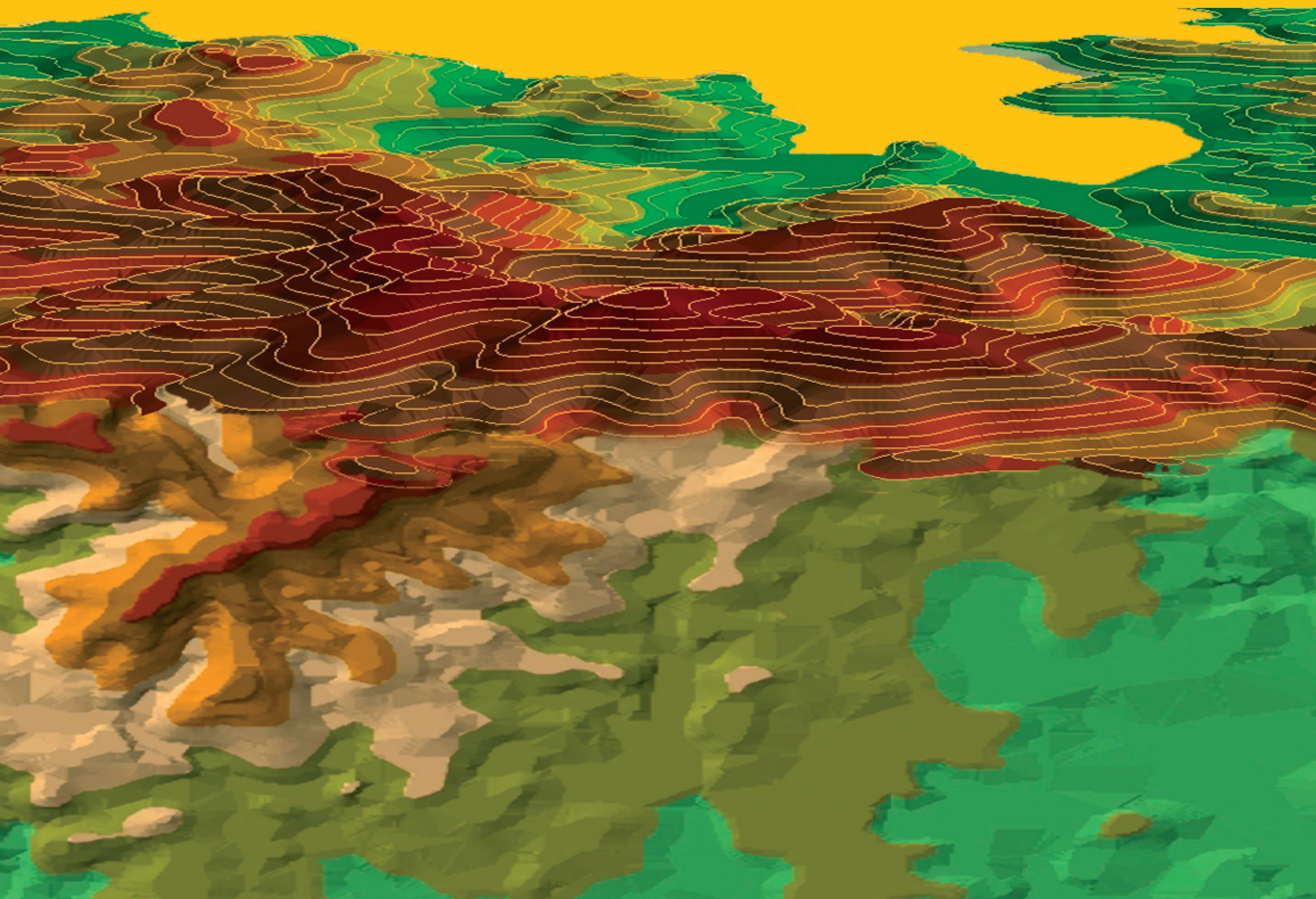

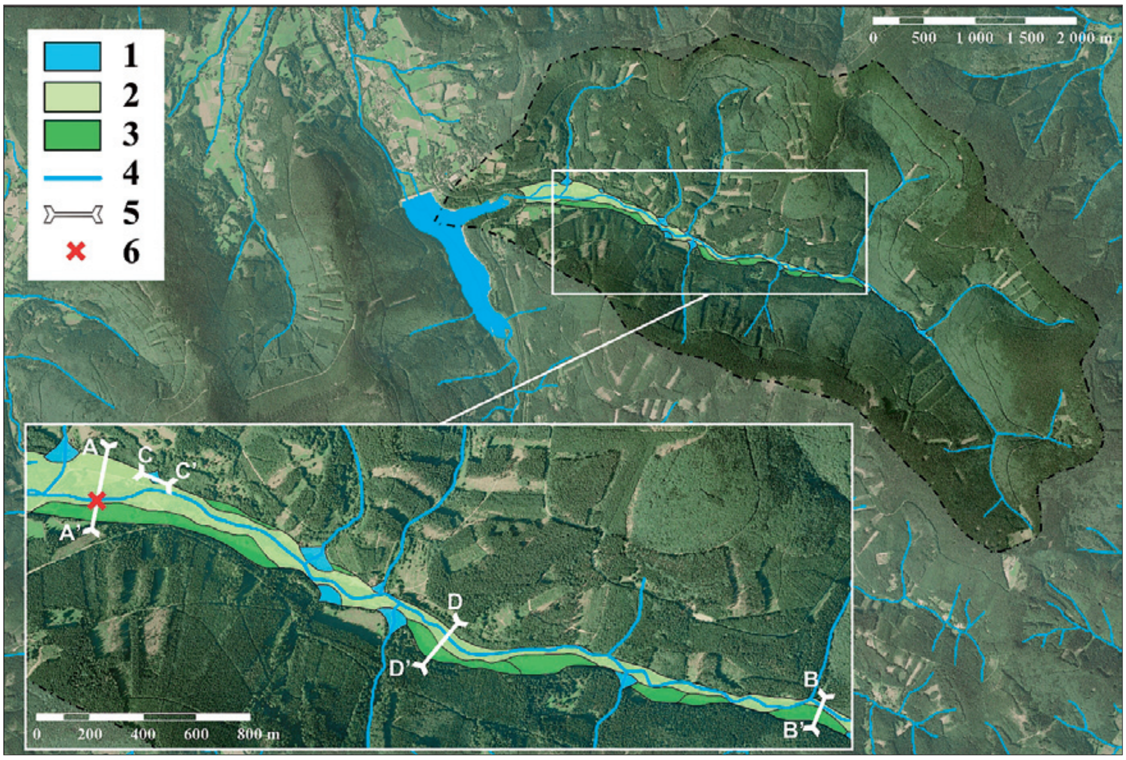

Fig. 3: Distribution of sediment storage types and localization of ERT profiles and studied outcrop in the Slavíč River basin

Fig. 10: Channel anabranching in the reach of ca. 400 m upwards from the mouth of the Morávka water reservoir (Photo: V. Škarpich)

Illustrations related to the paper by V. Škarpich, J. Hradecký and P. Tábořík

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THE ROLE OF REGION DELIMITATION IN A STUDY OF LAND COVER CHANGES: CASE STUDY FROM THE CZECH REPUBLIC AFTER 1990

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Abstract

Land cover changes in the Czech Republic after 1990 were analysed in this research. Using the CORINE database, differences and similarities in land cover changes in formal (geomorphological subprovinces) and functional (region) macroregions in the years 1990, 2000 and 2006 were recorded. To assess these changes, a change index and other statistical methods (particularly the Euclidean metric similarity matrix) were used. Political and other driving forces which could have influenced these changes were also considered. Using dendrograms, a typology of formal and functional macroregions was also established.

Shrnutí

Role vymezení regionů při studiu změn krajinného pokryvu: případová studie Česká republika po roce 1990

V článku jsou analyzovány změny ve využití území v České republice po roce 1990. Pomocí databáze CORINE, byly zjišťovány rozdíly a podobnosti ve změnách krajinného pokryvu ve formálních (geomorfologické subprovincie) a funkčních (krajích) makroregionech v letech 1990, 2000 a 2006. Pro posouzení těchto změn bylo použito změn indexů a dalších statistických metod (zejména Euklidovská matice podobnosti). V úvahu byly vzaty i politické a jiné hnací síly, které mohly mít vliv na tyto změny. Za použití dendrogramů byla vytvořena typologie formálních a funkčních makroregionů.

Keywords: *land cover changes, driving forces, formal and functional regions, Czech Republic*

1. Introduction

Although land cover and land use are interrelated, they are not synonymous terms (Jansen and DiGregorio, 2003). Burley (1961) properly presented how the meaning of land use should be understood: "Land use = land cover + land utilisation". Land use includes everything for which land is used by the country residents, from farms to golf courses, from houses to fast food establishments and from hospitals and graveyards. Land cover refers more specifically to vegetation and artificial constructions covering the land surface (Lindgren, 1985).

Land cover, which is principally the concern of natural sciences, denotes the physical state of the land; it encompasses, for example, the quantity and type of surface vegetation, water and soil. However, land cover classes include artificial or manmade areas (e.g., urban fabric, roads, ports, dump sites, mineral extraction sites). Land cover is defined as that which can be observed on the surface of the Earth, whereas land use relates to the manner in which these biophysical assets are used by humans (Cihlar, Jansen, 2001). Because the use depends largely on land characteristics (i.e., cover, form, position, substratum), there is a close relationship between land cover and land use.

Land cover changes in two ways: 1) conversion – a change from one class of land cover to another – from grassland to cropland, for example; and 2) modification – a change of conditions within a land-cover category, such as the thinning of a forest or a change in its composition (Coppin et al., 2004).

In addition, there are determining factors, such as institutional and cultural settings, legal attributes of the plot (e.g., land tenure and broader socio-economic environment). The made land use choices will vary in space and time.

Land use is a result of the interaction between physical, social, economic and legal factors within a spatial framework. Technical and methodological developments that will help to address land use issues and decision-making processes include spectral, spatial and temporal resolutions in remote sensing; the increased quantity and quality of data from existing and new remote sensing platforms; movement toward interoperability in GIS; and the construction of novel modelling methods that focus on the provision of an integrated understanding of land use systems (Hill, Aspinall, 2000).

For example, land use/cover patterns have been shown to affect ecological processes (Parker, Meretsky, 2004), community and species distributions (Peppler-Lisbach, 2003), and soil organic carbon stocks (Lettens et al., 2004; Smith et al., 2005). Knowing where land use change will occur is important for migratory bird species, in which population dynamics can be strongly influenced by land use change over large areas (Gauthier et al, 2005).

Jansen (2006) argues that knowledge about land use/cover changes has become increasingly important for the analysis of environmental processes and problems, such as uncontrolled urban development, deteriorating environmental quality, loss of prime agricultural lands, expansion of agriculture into areas that comprise fragile ecosystems (e.g., wetlands and steep lands), have a high value with respect to biodiversity (e.g., humid tropical forests) or areas that have a high incidence of diseases including malaria and river blindness.

In contrast, environmental changes have feedback effects on land cover, land use, and human driving forces. These effects, whether real or perceived, are associated with a further set of human dimensions to the extent that they provoke societal responses that are intended to manage or mitigate harmful changes.

Currently, the emphasis is shifting from static land use data collection and representation of data in maps towards more dynamic environmental modelling to understand the past, monitor the present situation and predict future trajectories (McConell, Moran, 2001; Dolman et al., 2003).

Land use / land cover changes reflect socioeconomic processes acting over a very wide range of spatial and temporal scales, including globalisation, trade and markets, policy and land management decisions at the national, regional, local, or household/individual level. McNeill et al. (1994) stated that one of the most significant human driving forces behind land use change was the political driving force (degree of public participation: open/closed, centralised/decentralised, and decision making processes).

Land cover changes are analysed within established, specific territories. One can compare the same territory at different times or different territories at the same time. To compare different territories, one uses some form of territorial subdivision, in most cases a subdivision that is already in place. However, the question remains whether this phase of the research might have a fundamental advance impact on the actual results. To what degree are the results of the land use/cover change analysis altered when different territorial subdivisions are selected? This problem takes on greater importance when two comprehensive territorial subdivisions are compared, one of which is based on natural factors and the other one is based on socio-economic factors.

Currently, the following research questions remain to be answered: What land cover changes have occurred in the post-communist Czech Republic? What are the prevalent trends in land cover developments? How has been land cover differentiated in individual Czech regions? How have the dynamics of land cover change shifted? Can regions be clustered into specific types? Can the typology of regions be formulated according to the character and dynamics of land cover change? How have been land cover changes reflected into other basic economic and social characteristics of Czech regions, and vice versa?

2. Methods

To monitor the internal heterogeneity of land cover in the Czech Republic and developments on a macroregional scale, we used the CORINE land cover (CLC) data. This is a useful database for analysing land cover and landscape developments, especially on regional and national (macro) scales. Our report concerns a territory of approximately 79,000 km^2 (total area of the Czech Republic).

The CLC1990 database was created by interpreting LANDSAT 5 TM satellite images made in the period from 1989–1992. Due to the need of updated land cover data, the European Environment Agency started to work with the European Commission's Joint Research Centre on IMAGE2000 and CLC2000 projects in 1999 (I&CLC2000, e.g. Perdigao, Annoni, 1997; Steenmans, Perdigao, 2001; Nunes de Lima, 2005; and Feranec et al., 2007). The IMAGE2000 project represented a database of satellite images of Europe taken from the LANDSAT 7 ETM satellite. CLC2006 is the direct continuation of earlier activities connected with the CORINE Land Cover mapping.

The main methodological principles for processing satellite images were maintained to be able to compare the databases. A minimum mapped unit was 25 ha;

mapped linear objects had a minimum width of 100 m. Only flat objects (polygons) were identified. The output was represented by land cover maps on a scale 1:100 000 with 44 land cover classes for Europe and 29 land cover classes for the Czech Republic (Tab. 1).

In general terms, the region is a basic geographical term. According to Haggett (1972), it is necessary to view this term with regard to why it is being used in the specific case and how it is defined. Some regions have an informational function, and other ones serve land use planning purposes. Some are designated on the basis of similar characteristics and other ones on the basis of functions they fulfil and connections within segments of the region. We used the methods for two types of macroregions in the Czech Republic. The first are formal regions (e.g. homogenous), and the second are functional regions (e.g. hub).

Formal regions are defined based on similar characteristics of the effects. These can be divided further into single and multiple regions according to the distinguishing features. Regions bordered by contours (isothermal curves) or watercourses serve as examples. Of the socio-geographical regions, demographic regions defined according to selected demographic characteristics can be noted. Functional regions are spatial systems based on internal spatial and functional interactions between the core (or node or focus) and its hinterland. The strength of the connections between the core and the hinterland is a criterion for specifying these regions.

To analyse the spatial differentiation of land cover classes in formal and functional macroregions, we used the following statistical methods: Euclidean metric similarity matrix, cophenetic correlation coefficient, cophenetic matrix and dendrogram. We made our calculations based on relevant data for land cover classes to prevent the results from being distorted due to varying sizes of the macroregions.

The Euclidean metric similarity matrix was calculated as an n^{th}-order Minkowski metric where n = 16. This is a generalised number of land cover classes existing in the Czech Republic. Due to their insignificant

1 Artificial surfaces	24 Heterogeneous agricultural areas
11 Urban fabric	242 Complex cultivation patterns
111 Continuous urban fabric	243 Land principally occupied by agriculture, with significant areas of natural vegetation
112 Discontinuous urban fabric	**3 Forest and semi-natural areas**
12 Industrial, commercial and transport units	31 Forests
121 Industrial or commercial units	311 Broad-leaved forests
122 Road and rail networks and associated land	312 Coniferous forests
123 Port areas	313 Mixed forests
124 Airports	32 Scrub and/or herbaceous vegetation associations
13 Mine, dump and constructions sites	321 Natural grasslands
131 Mineral extraction sites	322 Moors and heathland
132 Dump sites	324 Transitional woodland-scrub
133 Construction sites	33 Open spaces with little or no vegetation
14 Artificial, non-agricultural vegetation areas	332 Bare rocks
141 Green urban areas	334 Burnt areas
142 Sport and leisure facilities	**4 Wetlands**
2 Agricultural areas	41 Inland wetlands
21 Arable land	411 Inland marshes
211 Non-irrigated arable land	412 Peat bogs
22 Permanent crops	**5 Water bodies**
221 Vineyards	51 Inland waters
222 Fruit trees and berry plantations	511 Watercourses
23 Pastures	512 Water bodies
231 Pastures	

Tab. 1: Land cover classes monitored in the Czech Republic (CLC1990, CLC2000)

areas, classes 322, 332, 334, 411, 412 and 511 were omitted. For purposes of simplification, the following similar, relatively small classes were merged into four classes: 111 and 112; 121, 122, 123, 124 and 133; 131 and 132; 141 and 142.

The cophenetic correlation coefficient and cophenetic matrix express the degree of similarity between the macroregions and, through the dendrogram and expression of the distance, point out potential agglomerations and clusters of similar units.

In addition to the spatial differentiation of land cover classes in the two types of macroregions, we also ascertained the character and dynamics of development in terms of the land cover changes in 1990, 2000 and 2006. We calculated the change index designated for the class and for the specific macroregion as follows:

$$Iclc_i = 1000 * \frac{Area_{i,t2} - Area_{i,t1}}{Area * (t2 - t1)}$$

where $Area_{i,\ t2}$ is the area of the ith class in time t_2; $Area_{i,\ t1}$ is the area of the ith class in time t_1; i.e., at the start of the period; and *Area* is the total area of the macroregion. The total macroregion change index is the sum of absolute $Iclc_i$ values. The methods were applied to the formal and functional macroregions.

3. Czech Republic after the political shift in 1990

Post-communist developments in the Czech Republic following the 1989 "Velvet Revolution" included significant socio-economic changes, as well as changing consequences of human activity in the landscape. The political change affected land cover in various Czech macroregions in different ways and at different intensities. We monitored these changes in three specific time periods: 1990, 2000, and 2006 (Bičík and Jeleček, 2005). The years represent different transformation periods in the Czech Republic.

This was preceded by the period of government by a totalitarian communist state, from 1948–1989 (Hampl, 1998). In this period of totalitarianism, the Czech lands were in the final phase of the development of an industrialised society. However, development in the Czech Republic diverted from the natural trajectory of development in advanced European countries, where characteristics of post-industrial society started to appear. At the beginning of the totalitarian period, citizens with German nationality (approximately three million residents of German nationality) were displaced from the Czech lands. Following the expulsion, there was a wide-scale deterioration of the community structure. Homes and farms were destroyed; numerous historical and artistic landmarks disappeared and landscape structures and uses were unified. A centrally planned economy was introduced. In agriculture, central planning took the form of collectivisation and nationalisation of private property (fields as well as private enterprises), and a type of landscape designated as collective open fields was created.

In the transformation period (1990–2000), the Czech Republic transitioned from being a communist country into a free society with market economy. Prices were liberalised, and land and property were privatised. A new legislative and institutional environment was formed.

In the post-industrial period (beginning after 2000), communications and information networks burgeoned. The share of tertiary sector (services and tourism) in the country's overall GDP skyrocketed. Community structures stabilised. Reurbanisation occurred, and satellite towns within the reach of major settlement centres emerged. Even the once peripheral areas along the borders with Germany and Austria experienced economic development.

Formal and functional macroregions of the Czech Republic

The formal macroregions in the Czech Republic are geomorphological subprovinces (the second highest order in the Czech Republic in geomorphological regionalisation). Formal macroregions are formal types in the terminology of regional taxonomy. Subprovinces are defined by typical territories in which one or several main hill or mountain ranges are predominant (Fig. 1, Tab. 2), but they also include foothills and smaller neighbouring mountain units, usually with related geological structures and formations (Demek, Mackovčín, 2006; Balatka, Kalvoda, 2006). These are formal macroregions that are defined on the basis of many geomorphological and geological characteristics.

Fig. 1: Formal macroregions (geomorphological subprovincies) of the Czech Republic

Subprovincies	Area (ha)	Artificial areas	Arable land	Pastures	Cultivated patterns	Forests	Transitional woodland-shrub
SU	666,459	1.9	17.0	19.3	9.2	24.8	2.3
CM	2 204,706	4.3	44.5	5.8	10.0	33.1	0.8
KR	692,654	4.6	17.5	17.3	11.3	36.1	7.9
PO	806,701	7.8	41.9	5.0	7.0	35.5	1.0
CT	1,125,336	7.4	58.0	3.7	7.2	21.1	0.8
KJ	1,138,910	4.9	22.0	15.8	10.7	41.6	3.9
SN	39,214	12.3	67.6	1.4	6.1	8.3	2.5
VS	382,531	13.8	66.7	1.3	7.0	6.5	0.9
VP	98,247	8.0	48.7	2.3	6.9	24.8	1.5
VK	713,208	6.5	31.6	7.7	13.9	37.4	0.9
CZ	**7,867,967**	**5.8**	**38.1**	**8.9**	**9.6**	**33.1**	**2.0**

Tab. 2: Land cover structure of formal macroregions (CORINE, 2006; in %)
Notes: Šumavská (SU) Šumava sub-province, Českomoravská (CM) Bohemian-Moravian sub-province, Krušnohorská (KR) Krušné hory Mts. sub-province, Poberounská (PO) Berounka River sub-province, Česká tabule (CT) Bohemian Plateau sub-province, Krkonošsko-jesenická (KJ) Krkonoše-Jeseníky sub-province, Středopolské nížiny (SN) Central-Poland Lowlands, Vněkarpatské sníženiny (VS) Outer Carpathian depressions, Vídeňská pánev (VP) Vienna Basin, Vnější Západní Karpaty (VK) Outer Western Carpathians, Česko (CZ) Czech Republic, Artificial areas (classes 111, 112, 121, 122, 123, 124, 131, 132, 133), Arable land (class 211), Pastures (class 231), Forests (class 311, 312, 313), Cultivated patterns (class 242, 243), Transitional woodland-shrub (class 324)

The regions ("kraje") are the functional macroregions in the Czech Republic (Fig. 2). The macroregions west and south of Prague, in particular, are experiencing dynamic development (Jančák and Götz, 1997). Territories that were strongly peripheral in the past began to prosper after the fall of the Iron Curtain. Now, these form sort of a bridge between the Prague agglomeration and the "wealthy" parts of Germany and Austria (Tab. 3).

The changes in 1990 and the integration of the Czech Republic into the European Union were accompanied by more distinct market development in the western macroregions, which are becoming attractive for migrants and are also the target of foreign investment. In contrast, the eastern macroregions predominantly experience migration loss. As is also prevalent in other parts of Europe, the economic gradient in these regions apparently decreases from west to east.

Fig. 2: Functional macroregions of the Czech Republic

4. Results

We can generally state that the more broken the topography, the higher the average elevation (subprovinces of Šumava, Krušné hory Mts., Krkonoše–Jeseníky Mts.), and further to the west the macroregion is located, the more intense the land cover changes (Tab. 4). To a significant extent, this corresponds to previous developments in Western Europe (Germany and Austria). Changes in land cover category developments have spread to the Czech Republic from Germany and Austria and are encroaching farther eastward. Macroregions in lowlands (Polish Plain, Bohemian Plateau) and basins and ravines (Vienna Basin, Outer Carpathian Depressions) have greater land cover stability.

The shift of arable land to pastures represents the greatest land cover change, and again, this is the most intensive change in topographically broken, uneven areas. The absolute opposite is the case for the growth of artificial areas. It was interesting to find that in the western border area formal macroregions, the intensity of change was higher in the first period (1990–2000) than in the second one. In contrast, the intensity escalated in the eastern macroregions in the second period (Fig. 3).

Regions	Area	Population density	Population	Migration (increase or decrease)	Share in GDP (CR=100)	Share in GDP (EU25=100)	Registered unemployment rate	Agricultural land	Arable land	Cattles
	km^2	inh. per km^2	inh.	‰	%	%	%	%	%	thous.pcs
PH	496	2,386,2	1,183,576	5.3	24.0	154.8	2.7	41.9	30.8	
CC	11,013	105,9	1,166,537	14.1	10.4	68.6	5.3	60.5	50.3	153
JC	10,056	62,5	628,831	3.2	5.5	66.4	5.7	49.1	31.7	210
PL	7,561	73,1	552,898	5.7	5.0	69.4	5.6	50.5	34.8	156
KV	3,315	91,9	304,573	0.3	2.2	55.9	9.2	37.5	16.9	36
UL	5,334	154,3	823,193	-0.2	6.5	60.1	13.8	52.0	34.6	40
LB	3,163	135,9	429,803	3.3	3.5	62.4	7.0	44.4	21.6	41
HK	4,758	115,4	549,122	2.7	4.7	65.0	6.3	58.7	40.6	109
PR	4,519	112,2	506,808	3.2	4.1	61.0	6.9	60.5	44.2	120
VY	6,926	73,8	511,114	1.1	4.2	62.7	7.1	59.5	46.1	216
JM	7,067	160,0	1,130,990	2.1	10.0	67.4	8.8	61.0	50.7	75
OL	5,139	124,4	639,423	0.9	4.7	56.1	9.0	54.8	40.8	97
ZL	3,964	148,8	589,869	0.0	4.7	59.8	7.8	49.3	31.7	59
MS	5,555	225,0	1,249,909	-1.0	10.4	63.2	12.6	49.9	31.4	79

Tab. 3: Basic attributes of the functional macroregions – in 2008 (Source: Czech Statistical Office)
Notes: Praha (PH) Prague, Středočeský (CC) Central Bohemia, Jihočeský (JC) South Bohemia, Plzeňský (PL) Pilsen, Karlovarský (KV) Karlovy Vary, Ústecký (UL) Ústí n. L., Liberecký (LB) Liberec, Královéhradecký (HK) Hradec Králové, Pardubický (PR) Pardubice, Vysočina (VY) Bohemian-Moravian Upland, Jihomoravský (JM) South Moravia, Zlínský (ZL) Zlín, Olomoucký (OL) Olomouc, Moravskoslezský (MS) Moravian-Silesian

Subprovincies	Artificial areas	Arable land	Pastures	Cultivated patterns	Forests	Transitional woodland-shrub
SU	0.10	-8.07	7.24	1.48	0.38	-0.98
CM	0.22	-3.55	2.41	1.71	0.50	-1.32
KR	0.13	-7.02	7.69	1.81	-0.31	-1.21
PO	0.33	-2.82	1.69	0.99	0.72	-0.86
CT	0.38	-2.17	1.28	0.45	0.31	-0.14
KJ	0.20	-7.00	6.71	0.18	-0.13	0.07
SN	0.27	-0.51	0.04	-0.82	0.09	0.96
VS	0.30	-1.06	0.43	0.13	0.26	-0.07
VP	0.17	-2.00	0.12	0.73	0.66	-0.72
VK	0.10	-3.57	2.68	0.47	0.49	-0.37
CZ	**0.19**	**-4.30**	**3.54**	**1.01**	**0.31**	**-0.70**

Tab. 4: Index of land cover changes in the formal macroregions in 2006/1990 (CORINE) – for explanation of categories and abbreviations see Tab. 2 and 3

The changes in the development of land cover classes in functional macroregions, were, in most cases, more intense than in formal macroregions. For the classes with the most intensive changes, these were: an average index of land cover changes of formal macroregions (arable land/pastures) of 4.20/3.65, and the average index of land cover changes of functional macroregions (arable land/pastures) was 4.58/4.01. The growth of artificial areas in Prague and the hinterlands are due to the "hub" location of this macroregion, which is notable for its high representation of managers and high contribution to GDP (35% of the Czech Republic).

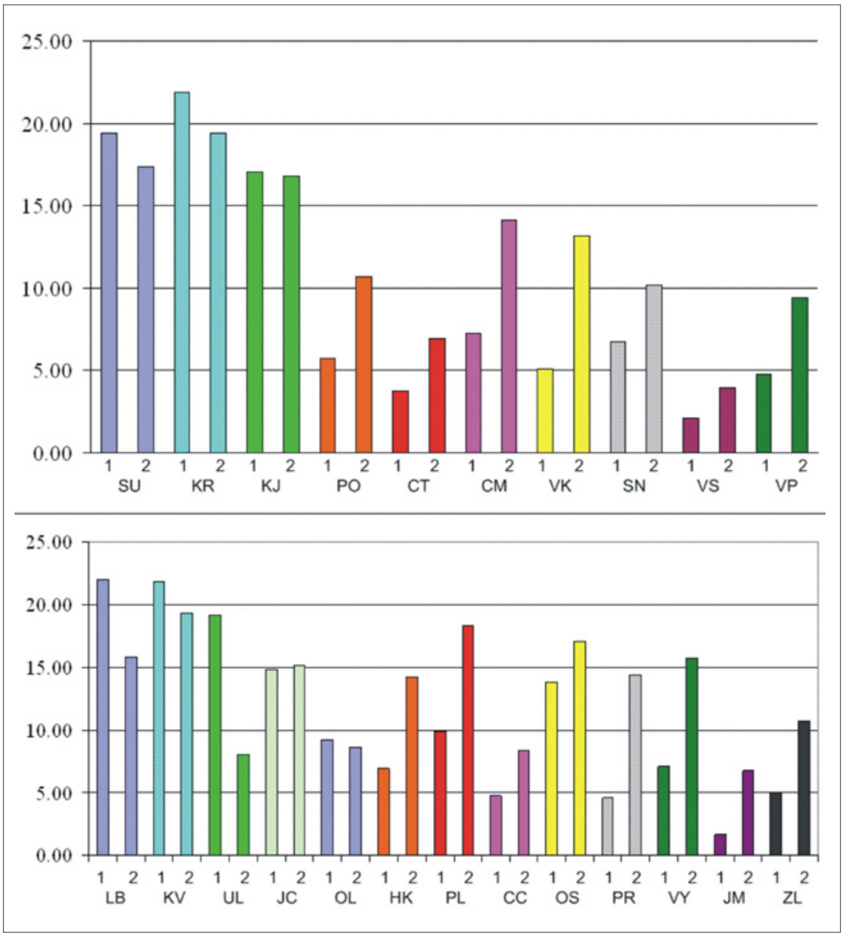

Fig. 3: Development of the total index of land cover changes (CORINE) – for explanation of categories and abbreviations see Tab. 2 and 3
Notes: 1 – total index of land cover changes in 2000/1990, 2 – total index of land cover changes in 2006/2000

Tab. 5 demonstrates that the decrease in arable land was, again, most dynamic in macroregions with a broken, uneven terrain (Karlovy Vary and Liberec regions) or in "regression" macroregions, which due to their skewed focus on industry, became troubled areas after 1990 (Ústí nad Labem and Moravian-Silesian Regions). Another typical attribute of these macroregions was the dynamic growth of meadows and relatively forested areas.

Although far less dynamic, similar developmental trends could be observed in two "prospering" macroregions that are developing mainly because of their advantageous location along the borders with Germany and Austria (South Bohemian and Pilsen Regions). Minimal changes in developments for land cover classes were observed in the South Moravian and Zlín Regions. As with formal macroregions, the dynamics of change in these regions decrease as the terrain becomes less broken and as one moves from the west to the east (Fig. 3).

Fig. 4 confirms that for formal macroregions, land cover is becoming increasingly differentiated. However, the two most similar macroregions (the Poberounská sub-province and the Českomoravská sub-province represent an exception. Although the most similar pair of macroregions has remained the same, the most heterogeneous macroregion pair (Šumava sub-province and Outer Carpathian Depressions) has been joined by an additional pair: the Šumava sub-province and the Central Polish Lowlands. The number of distant connections has gradually increased from 11 to 18. Two close connections have remained. The number of intermediate connections fell from 13 to 8. The average value dropped from 6.4 to 5.5, and the maximum increased from 57.1 to 68.9.

Figure 5 confirms the differentiation of land cover structure in formal macroregions. Three basic clusters of formal macroregions are gradually being formed:

1. Krušné hory Mts., Krkonoše–Jeseníky Mts. and Šumava sub-province;
2. the Outer Western Carpathians, Bohemian-Moravian Highlands, Beroun sub-province; and
3. the Central Polish Lowlands, Bohemian Plateau, Outer Carpathian Depressions and, in part, the Vienna Basin.

Regions	Artificial area	Arable land	Pastures	Forests	Cultivated patterns	Transitional woodland-shrub
Prague+CC	1.50	-2.50	1.12	1.01	0.69	-0.47
JC	-0.19	-5.76	4.65	1.83	0.59	-1.38
PL	0.14	-5.51	4.49	1.14	0.70	-0.92
KV	0.01	-7.53	8.32	1.98	-0.68	-0.94
UL	0.20	-8.26	8.81	2.48	0.20	-2.14
LB	0.33	-8.23	7.56	1.16	0.00	-0.43
HK	0.33	-4.68	3.93	0.11	0.26	0.01
PR	0.42	-3.49	2.85	0.34	0.05	-0.19
VY	0.14	-3.43	2.20	2.02	0.73	-1.70
JM	0.23	-1.22	0.16	0.32	0.40	-0.25
OL	0.18	-3.10	2.68	-0.08	0.03	0.34
ZL	0.01	-0.33	0.26	0.03	0.05	-0.02
MS	0.16	-5.49	5.11	0.55	-0.03	-0.37

Tab. 5 : Index of land cover changes in the functional macroregions in 2006/1990 (CORINE) – for explanation of categories and abbreviations see Tab. 2 and 3

The situation is somewhat different for the functional regions, where significantly less differentiation can be found between the structures of individual macroregions. In spite of this, Fig. 6 shows that the functional macroregions are becoming increasingly diversified too. The intensity of change between the years is greater than for formal macroregions. However, the pair of most similar macroregions (South Bohemia Region and Pilsen Region) represents an exception. The most similar pair of macroregions in 1990 (Hradec Králové and Olomouc Regions 4.1) has been replaced by the South Bohemia and Pilsen Region (3.8). Excluding Prague, the most different pair of macroregions has remained stable, representing the Karlovy Vary and South Moravia Regions. Excluding Prague, the number of distant connections has gradually increased from two to ten. The number of close connections has dropped from ten to eight. The number of intermediate connections has fallen from 36 to 25. The minimum value has decreased from 4.1 to 3.8, and the maximum value (excluding Prague) has increased from 41.3 to 52.1.

Figure 7 confirms the less marked differentiation of land cover structures in formal macroregions. A major central cluster composed of the Pardubice, Central Bohemian, Olomouc, Hradec Králové, South Moravian and Vysočina Regions is forming. These macroregions represent areas with a higher concentration of junctions in the Czech Republic – not just in terms of geographical location but also in terms of land cover structure. Compared with this cluster, other clusters are smaller and less cohesive. The South Bohemian – Pilsen Region pair represents an exception. The following clusters can be considered somewhat subject to fluctuation and less cohesive: 1) Ústí nad Labem, Zlín and Moravian-Silesian Regions, and potentially also 2) Liberec, Karlovy Vary and Moravian-Silesian Regions.

5. Discussion and conclusions

Political driving forces were the main reason behind land cover changes in the Czech Republic after 1990 (according to McNeill et al., 1994). These were associated with the transformation of centrally-planned economy into market economy. Moreover, the economic driving forces were followed by political forces due to which the consequences included a change in the composition of agricultural crops (area of grains decreased by 25%, sugar beet area by 55%), reduction in livestock production (cattle stock dropped by 45%), fall in the number of workers in agriculture (by 38%) and increase in the number of independent farmers (from 3,000 family farms in 1990 to 70,500 farms in 1999). Most affected by the Czech Republic's admission to the European Union was the sugar industry. Although sugar beets had been grown on 120,000 hectares of land in 1990, by 2008 this fell to just 50,000 hectares. The reason was the low quota for sugar production, which does not even cover the Czech Republic's own consumption.

As a result, this once traditional sugar exporting country turned into an importer. Although there were 52 sugar refineries in Czech lands in the 1980s,

1990	VP	VK	SN	VS	KJ	CT	CM	PO	SU	KR	Ar. mean
VP		21,7	23,0	21,2	34,6	*17,5*	22,7	23,3	**44,5**	32,3	26,8
VK			**35,8**	**37,2**	*17,9*	26,6	*18,7*	*16,5*	30,6	*16,0*	24,6
SN				6,8	**45,0**	*11,9*	27,7	30,3	**54,9**	**45,7**	31,2
VS					**47,5**	*14,9*	30,3	33,0	**57,1**	**47,2**	32,8
KJ						34,4	*19,1*	*16,0*	*13,9*	*12,5*	26,8
CT							*16,6*	*19,5*	**44,0**	**36,1**	24,6
CM								6,4	28,0	23,5	21,5
PO									25,6	21,1	21,3
SU										22,2	35,7
KR											28,5
						total	2463		**mean**	27,4	

2000	VP	VK	SN	VS	KJ	CT	CM	PO	SU	KR	Ar. mean
VP		22,6	24,8	21,6	**39,0**	*17,3*	23,9	24,0	**50,6**	**40,6**	29,4
VK			**39,2**	**38,6**	20,3	27,4	*19,9*	*17,5*	34,9	21,8	26,9
SN				6,8	**53,1**	*15,1*	32,0	34,0	**64,8**	**56,3**	36,2
VS					**53,1**	*15,4*	32,1	34,2	**64,3**	**55,9**	35,8
KJ						**39,8**	25,3	22,4	*16,4*	*11,1*	31,2
CT							*17,5*	*19,9*	**50,7**	**44,3**	27,5
CM								6,3	34,4	32,3	24,9
PO									32,3	29,5	24,5
SU										23,0	41,3
KR											35,0
					total	2813			**mean**	31,3	

2006	VP	VK	SN	VS	KJ	CT	CM	PO	SU	KR	Ar. mean
VP		23,9	25,5	22,3	**41,1**	*17,1*	24,5	24,3	**53,4**	**40,4**	30,3
VK			**41,5**	**41,2**	21,0	28,9	*19,6*	*17,7*	**36,0**	20,7	27,8
SN				7,7	**56,3**	*15,9*	34,8	**35,7**	**68,9**	**57,8**	38,2
VS					**56,4**	*16,1*	34,7	**35,8**	**68,4**	**57,4**	37,8
KJ						**42,2**	25,5	23,8	*16,6*	*11,5*	32,7
CT							*19,4*	20,7	**54,0**	**44,9**	28,8
CM								5,5	**35,6**	31,0	25,6
PO									34,7	29,3	25,3
SU										23,4	43,4
KR											35,1
					total	2926			**mean**	32,5	

Fig. 4: Euclidean Distance Matrix of formal macroregions in 1990, 2000, 2006 – for explanation of abbreviations see Tab. 2
Notes: underlined number – 0-10, italics 10-20, bold number 35 and above

there are only seven at the present. In contrast, rapeseed oil crop areas grew dynamically due to high subsidies in connection with the alternative fuel production. As a result of low quotas set by the EU and due to cheap milk and dairy imports from Poland, dairy cow stocks have continued to decrease.

In addition to the above-described reasons, determination by using natural factors has had an impact on the differentiation of land cover changes at the macroregion level in the Czech Republic. After the market economy developed, production costs (including food) started to become more important, thus indirectly separating areas suitable in the Czech Republic for concrete agricultural activities from areas that are less appropriate. The formation to market economy therefore represented a significant pressure on the adaptation to natural and new economic (market) conditions.

After the agriculture land had been returned to original owners, in the majority of cases, the new owners were not interested in the land and let it lie fallow (waste). Moreover, the growing of agricultural crops is becoming increasingly concentrated in the most fertile areas with the best climate. In connection with the population's growing demands for quality housing and transformation to post-modern society, satellite towns in the hinterlands of large agglomerations are being constructed (suburbanisation), or in some cases, the village mode of living is becoming urbanised through the construction of houses and villas (reurbanisation). As a result, the developed residential space is increasing. Space for industrial and retail operations is growing too, in most cases in connection with the transport infrastructure developing along newly constructed highways and motorways. According to the structure

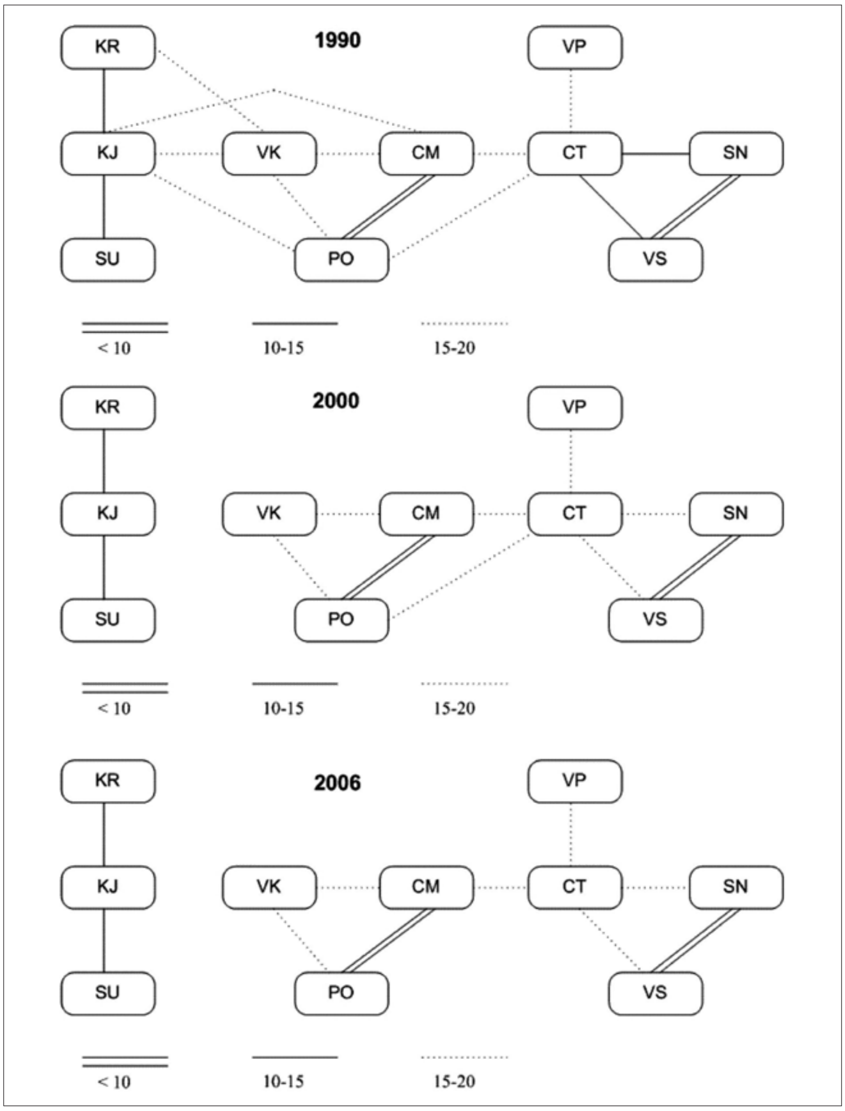

Fig. 5: Clustres of formal macroregions according to Euclidean Distance and Cophenetic correlation coefficient – for explanation of abbreviations see Tab. 2

and development of land cover in the Czech Republic, the national typology can be organised on the macroscale (Fig. 8) as follows.

Formal macroregions

The first type of formal macroregion predominantly includes mountain (border-area) macroregions. The second type is represented by hilly and highland macroregions. The third type encompasses lowland and basin macroregions, where land cover changes have been minimal. In general, it has been shown that the dynamics of change decrease from west to east and with diminishing elevation.

Functional macroregions

The first type is relatively homogenous internally. It has good natural conditions (especially land and climate) for agriculture, and in terms of geographical location and accessibility, it also has good conditions for overall economic development. A high degree of stability in developments in the main land cover classes is typical for this type. Agricultural land is owned largely by cooperatives, and cooperative groups mainly farm on fertile chernozems. This can be characterized as a hub area in the Czech Republic with the growing pressure on land in the hinterlands of Prague and along the main arteries.

The second type is very homogenous due to its exposed geographical location neighbouring Germany (Bavaria) and Austria. Economically, it is developing well. There is low unemployment and a significant focus on tourism. The land in this type of macroregion, which is less fertile and more suitable for grazing, is owned predominantly by cooperatives. There has been dynamic growth in pasturelands and, to some degree, also in forested lands.

The third type includes macroregions that have been affected most significantly by the political changes and the transformation from centrally-planned economy to

1990	ZL	UL	CC	PL	PH	PR	MS	OL	LB	KV	HK	VY	JC	JM	Ar. mean
ZL		11,0	20,2	25,0	34,6	21,0	14,2	15,9	20,1	28,8	17,1	25,0	22,2	18,2	19,5
UL			17,3	25,0	34,4	18,9	15,8	14,1	21,3	29,3	15,4	22,0	21,9	16,8	18,8
CC				23,3	40,3	8,9	23,4	7,0	29,5	37,3	9,3	11,6	21,9	10,2	18,6
PL					47,0	15,3	16,2	18,0	16,9	19,5	15,0	16,0	4,8	29,7	19,4
PH						41,7	37,4	38,1	42,2	48,4	39,3	45,2	43,0	37,6	37,8
PR							19,2	7,0	24,3	31,1	4,9	5,2	14,3	17,5	16,4
MS								17,7	7,5	17,4	16,2	22,6	13,0	26,9	17,7
OL									23,7	31,2	4,1	11,0	16,2	12,3	15,4
LB										10,8	22,0	26,7	14,5	33,4	20,9
KV											29,1	32,4	18,3	41,3	26,8
HK												9,4	13,3	15,8	15,1
VY													15,7	20,2	18,8
JC														27,9	17,6
JM															22,0
								total	3987				mean	20.3	

2000	ZL	UL	CC	PL	PH	PR	MS	OL	LB	KV	HK	VY	JC	JM	Ar. mean
ZL		10,9	21,0	26,0	35,8	21,2	15,5	15,2	26,2	34,6	16,5	26,8	24,0	20,3	21,0
UL			23,9	26,5	35,8	23,0	12,7	16,7	23,0	31,2	17,6	29,0	24,0	24,8	21,4
CC				25,5	41,7	8,7	27,6	8,9	38,9	45,9	11,2	12,8	25,9	10,6	21,6
PL					48,7	17,8	19,1	20,4	22,9	25,8	16,3	18,1	4,6	32,8	21,8
PH						42,6	38,5	38,3	46,5	53,1	40,0	47,7	45,8	39,7	39,6
PR							23,2	8,2	33,4	39,5	6,4	6,7	18,4	17,9	19,1
MS								20,1	12,3	21,4	18,2	28,0	15,8	31,6	20,3
OL									31,4	38,2	5,2	14,5	19,9	13,9	17,9
LB										10,6	28,8	36,9	19,8	43,4	26,7
KV											35,3	41,8	23,3	50,6	32,2
HK												12,3	15,8	18,0	17,3
VY													19,9	22,0	22,6
JC														32,7	20,7
JM															25,6
								total	4588				mean	23,4	

2006	ZL	UL	CC	PL	PH	PR	MS	OL	LB	KV	HK	VY	JC	JM	Ar. mean
ZL		9,5	21,9	26,0	36,7	20,6	16,1	16,1	25,5	34,3	16,0	26,3	24,4	22,0	21,1
UL			23,4	26,4	36,8	21,2	16,0	16,6	24,6	32,8	15,5	27,3	24,7	24,2	21,4
CC				28,1	42,3	9,7	29,1	8,6	39,8	46,7	13,9	13,7	28,0	11,2	22,6
PL					49,6	19,1	16,8	22,3	21,2	22,9	17,0	19,1	3,8	35,9	22,0
PH						42,5	40,3	39,4	47,0	54,4	40,3	47,8	46,9	40,7	40,3
PR							22,7	7,2	32,7	38,7	7,0	7,4	19,0	19,2	19,1
MS								22,0	11,1	20,4	17,3	26,9	14,4	34,1	20,5
OL									32,5	39,2	6,9	13,9	21,8	14,5	18,6
LB										11,4	27,5	35,8	19,2	44,8	26,6
KV											33,8	40,4	21,6	52,1	32,0
HK												13,3	16,3	20,7	17,5
VY													19,8	23,4	22,5
JC														35,4	21,1
JM															27,0
								total	4655				mean	23,7	

Fig. 6: Euclidean Distance Matrix of functional macroregions in 1990, 2000, 2006 – for explanation of abbreviations see Tab. 3
Notes: underlined number – 0-10, italics 10-20, bold number 35 and above

market economy. This different situation stems from their long-term economic orientation focussed on energy, mining, steel and chemical industries – i.e. sectors that have negative impacts on the natural and social environment (Balej et al., 2008). At present, these areas are characterised by low economic performance and long-term high unemployment. Large agglomerations with a high degree of urbanisation form the core area of the macroregions. Natural conditions are not very suitable for agriculture. The labour force has typically a lower representation of university-educated people.

The smallest macroregions (Karlovy Vary and Liberec Regions) exhibit a broken, uneven terrain with a high percentage of forests and below-average natural conditions for (intensive and extensive) agriculture operations. This fourth type has experienced highly dynamic changes in the development of land cover classes. In the period from 1990–2000, almost half of the arable land was transformed into meadows. In these macroregions, it is predominantly business entities that farm on the agricultural land.

Land cover changes have been very different in individual types of macroregions. In all time periods, the Czech Republic is more differentiated in its formal regions both in terms of Average Euclidean Distance (AED) indicators and in the range of variation (R), which is due to the construction of both types of regions. Fundamentally, the formal

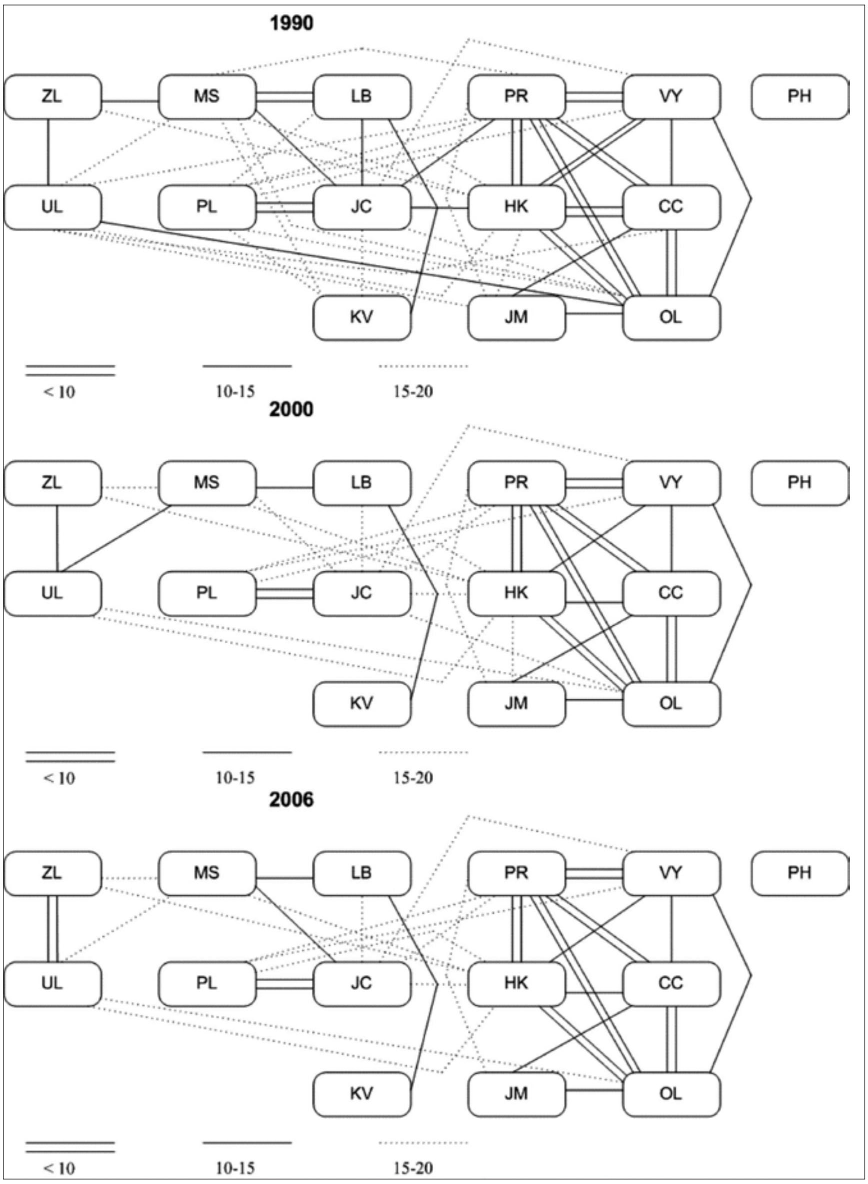

Fig. 7: Clustres of functional macroregions according to Euclidean Distance and Cophenetic correlation coefficient – for explanation of abbreviations see Tab. 3

regions are logically more homogenous. They are designated predominantly for comprehensive (quasi-homogenous) natural conditions. There is a greater heterogeneity of the land cover structure. In the functional macroregions, the changes in the development of land cover classes are significantly more dynamic – and are far more complicated too. Functional macroregions have land cover structures that are more similar to one another. The range of variation increased dynamically in both time periods. Whereas the AED indicator showed practically no change between 2000 and 2006 (Tab. 6), the range of variation increased relatively markedly in the functional regions (by 15.3%), although in the formal regions, the growth was far less dramatic (only 8.4%). This demonstrates the polarity of changes in the development of land cover classes. Macroregions that were very different due to their land cover structures were also observed to vary increasingly (AED for the Šumava sub-province and the Central Polish Lowlands increased by 25.5%), although there are macroregions with similar land cover structures that are becoming even more similar.

Another consistency that was found in the spatial differentiation and its development is shown by the trend of the wave of innovation moving from west to east. Western macroregions in the Czech Republic exhibited more dynamic changes in the development of land cover classes between 1990 and 2000. In most eastern macroregions, greater changes occurred in the second period, from 2000 to 2006 (Fig. 3). An exception is the Pilsen Region, where "overdue changes" also occurred in the second period. This is likely to be connected with the existence of internal peripheries in the northern section of the macroregion.

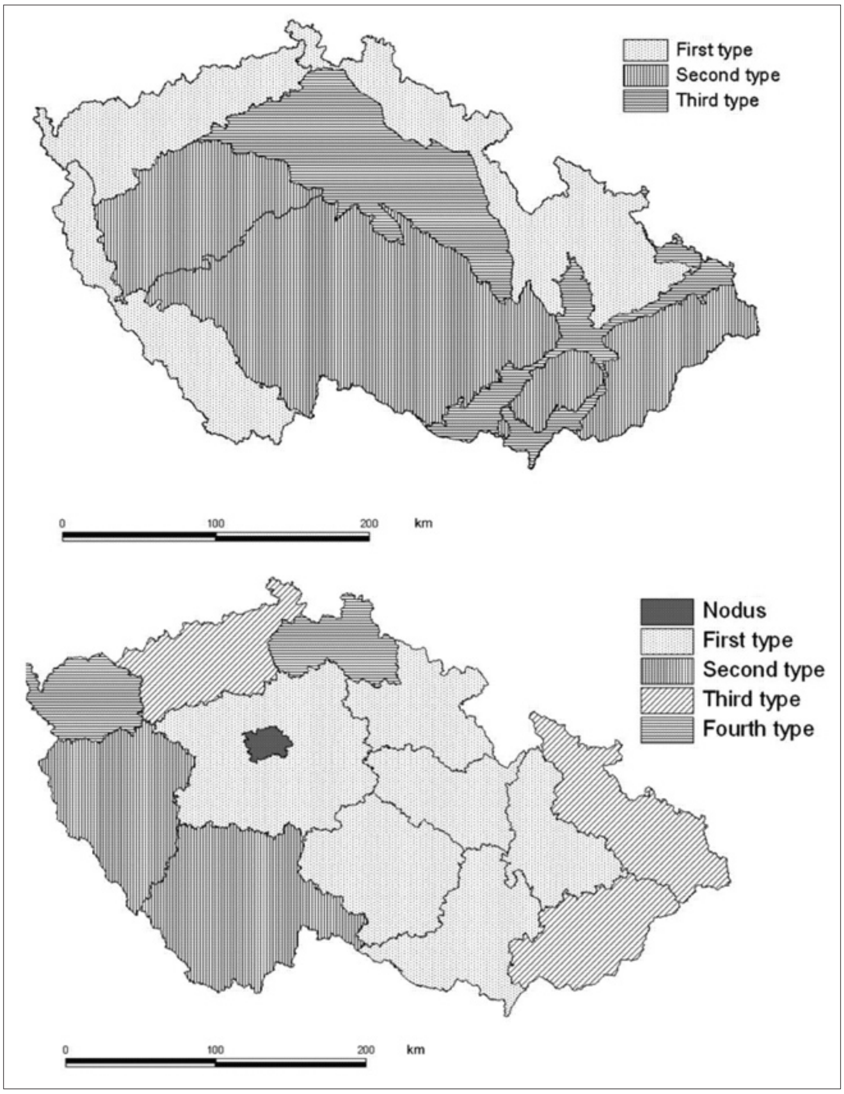

Fig. 8: Typology of formal and functional macroregions according to the structure and intensity of land cover changes

Macroregion	1990		2000		2006	
	AED	R	AED	R	AED	R
Formal	27.4	50.7	31.3	58.5	32.5	63.4
Functional	20.3	33.2	23.4	41.9	23.7	48.3

Tab. 6: Average Euclidean Distance (AED) and range (R) of macroregions in 1990, 2000 and 2006

Many similar conclusions can be made with respect to land cover changes in post-communist countries in Europe in the latter half of the 20th century (e.g., Brandt et al., 1999; Bűrgi et al., 2004; Schneeberger et al., 2007). This type of development, which is specific to these countries, was marked by a major recession in agricultural activities, as was most significantly apparent in the decrease of livestock production. In some countries, livestock populations dropped by up to a third, and in the Baltic countries, they fell by as much as 50%. Although 80% of agricultural land was privately owned in Poland, in other post-communist countries, private owners practically did not exist.

Between 1990 and 2000, there was also a major drop in the percentage of people employed in agriculture (in most cases nearly 50%). However, in this case as well, there are major differences (in the Czech Republic 5% of the population is employed in agriculture, although in Slovakia this figure is 9%, and in Poland, it is as high as 22%). Food production also plummeted. The greatest decreases were reported in Bulgaria (50%), Hungary (23%) and Poland (17%). Romania experienced the lowest decrease (5%). During the transformation period, the percentage of arable land was reduced predominantly in favour of meadows and forests, which was also the case of the

Czech Republic. In nearly all of the countries under transformation, the arable land area fell by 10%. The exception was Romania, where the total area stagnated. The situation stabilised in the period from 2000 to 2006. The differences between Central European countries continued to decrease slightly. In Poland, for example, the employment in agriculture fell from 22% to 16%. In this period, 50,000 jobs were lost in the Czech agriculture sector (which represents a drop by 20%), and the percentage of people employed in the agriculture sector fell to 3.6%.

Peterson and Aunap (1998) uncovered a trend that is similar to that observed in the Czech Republic when they found a significant loss in farmland area in Estonia from 1992 to 1996. Nearly a quarter of the arable land in the region stopped being used for farming, and the land left to lie fallow increased by twenty-fold. Lörinci and Balázs (2003) studied the historical land use and landscape development in Hungary, and Skowronek et al. (2005) carried out the same type of study in mid-eastern Poland. Nikodemus et al. (2005) investigated the impact of economic, social and political factors on the landscape structure of the Vidzeme Upland area in Latvia. They arrived at similar conclusions as were those in the studies listed above. In the first half of the 20th century, the Latvian countryside was a mosaic with a dense network of individual farms. Following World War II, extensive areas of land were abandoned due to the population loss and deportation of Latvians to Russia. Property was subsequently collectivised (only 6% of farms remained privately owned). Marginal land was left to lie fallow despite the fact that a regime of central planning for villages was adopted. Following the agricultural reforms in the 1990s, property was returned to its former owners, and small farms (up to 2 ha) are once again predominant. However, less than 50% of the currently existing agricultural land is being farmed. Extensive areas of land remained deserted, and the natural process of succession has set in – they are becoming overgrown with bushes and shrubs.

Land use/cover changes in Russia were investigated by Milanova et al. (1999). Hietel et al. (2004) analysed land cover changes in Germany from 1945 to 1995 in relation to selected environmental factors (broken terrain, elevation). Palang et al. (2006) analysed four model areas in Central and Eastern Europe (Slovenia, Hungary, Estonia and Poland). They came to the conclusions that man's estrangement from the countryside leads to a loss of the landscape's traditional identity and, subsequently, causes additional environmental problems. People do not identify with the landscape as much as they once did. The landscape is changing very dynamically. The rate at which the change is taking place in the countryside is increasing. Similar trends have been observed in a large number of other post-communist countries in Europe.

Together with other factors, political changes significantly affected the structure and development of land cover in Czech macroregions from 1990 to 2006. In terms of the structure of land cover classes, it was shown that a growing heterogeneity exists in Czech regions. At the beginning of the transformation period (before 1989), the uniformity of central planning was strongly evident. The role of natural conditions was relatively unimportant. In the following periods, the suitability of natural conditions became crucial.

The evaluation of developmental trends in land cover classes in comparison with current driving forces can indicate the next direction of development. Changes in the spatial differentiation and changes specifying how the changes can develop on the macroregional level are also important. Significantly, different developments can be observed in the formal regions as compared with the functional regions. With regard to these differences, it is critical to assess very carefully, which type of region should be selected to monitor land cover developments. Moreover, it would be very effective to apply methods used for hierarchically lower territorial units (e.g. NUTS-4 in the Czech Republic).

Acknowledgement

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THE PRESENT-DAY GEOMORPHIC ACTIVITY OF ALLUVIAL FAN (A CASE STUDY FROM THE MORAVSKOSLEZSKÉ BESKYDY MTS. BASED ON DENDROGEOMORPHOLOGICAL METHODS

Karel ŠILHÁN, Václav STACKE

Abstract

Alluvial fans are important landforms whose origin and evolution is the result of a wide range of geomorphological processes. Records on the evolution of alluvial fans in the Moravskoslezské Beskydy Mts. (Moravian-Silesian Beskids Mts.) are so far lacking. This study analyses current processes at work on the surface of a selected alluvial fan making use of dendrogeomorphic methods. The growth-disturbance analysis of 30 increment cores together with the cell-anatomy analysis of 12 exposed roots revealed that 13 accumulation and 7 erosional events occurred on the alluvial fan in the last 45 years. The origin of almost all the dated processes can be correlated with extreme meteorological events such as short-term rains of very high intensity or rapid snow thawing in spring.

Shrnutí

Současná geomorfologická aktivita na aluviálním kuželu (příkladová studie z Moravskoslezských Beskyd (Česká republika) s využitím metod dendrogeomorfologie)

Aluviální kužely jsou významnou formou reliéfu, jejichž vznik a vývoj je spojen s pestrou škálou geomorfologických procesů. Podrobné záznamy o vývoji aluviálních kuželů v Moravskoslezských Beskydech však dosud chyběly. V této studii byly procesy, modelující dnešní povrch vybraného kuželu, analyzovány pomocí dendrogeomorfologických metod. Analýzou růstových disturbancí z 30 vrtných jader a analýzou anatomických změn buněk z 12 obnažených kořenů bylo zjištěno 13 akumulačních a 7 erozních událostí na kuželu za posledních 45 let. Vznik téměř všech datovaných procesů je možné vysvětlit extrémními meteorologickými událostmi, jako jsou velmi vysoké krátkodobé srážky nebo rychlé jarní tání sněhu.

Key words: *dendrogeomorphology, alluvial fan, erosion, debris flow, Moravskoslezské Beskydy Mts., Czech Republic*

1. Introduction

Alluvial fans occur in abundance on almost all relief types (Harvey et al., 2005). Source basin parameters determine the dominant processes at work on the formation of alluvial fans. In principle, two major types of processes can be distinguished: slope processes dominate in the morphometrically defined and rather exposed areas (e.g. mountain units), whereas fluvial processes act on the less dynamic relief. Generally, however, these two types of processes alternate. Surface morphology of alluvial fans whose evolution is controlled by the activity of debris flows shows the presence of erosion channels, longitudinal levees and accumulation lobes (Jackson et al., 1987; Kostaschuk et al., 1986; Bollschweiler et al., 2008). On the other hand, the morphology of alluvial fans controlled by fluvial processes is flatter and characterized by the branching channels of permanent or intermittent streams. Potentially, changes in environmental conditions can bring about a total change in the type of process affecting a fan, with this often accompanied by erosive deepening of existing channels. A radical change in fan-surface formation processes can be caused by a distinct climatic change, by a change in the base level or by anthropogenic interference into land use. Although alluvial fans represent a common feature in the Moravskoslezské Beskydy Mts. (Šilhán, 2009), a detailed analysis of their evolution focusing especially on fan-forming processes has yet to be accomplished.

Dendrogeomorphic methods were used to carry out a detailed analysis of a selected alluvial fan in the eastern part of the Moravskoslezské Beskydy Mts. This approach enables a highly accurate analysis of accumulation slope processes (Strunk, 1997), fluvial processes (Gottesfeld and Gottesfeld, 1990) and erosive processes (Malik, 2008). Dendrogeomorphic methods start from the basic premise: process – event – response (Shroder, 1978; 1980). A process is understood as any geomorphological feature (e.g. a debris flow) that causes an event, e.g. stem damage on a tree. If the tree survives the event, its further growth represents a response to the event (e.g. callous tissue is formed and the injury is overgrown to leave a scar). This study deals with the effect that accumulation processes have on the growing trees (Stoffel and Bollschweiler, 2008, 2009) and also with the tree root exposure caused by the vertical deepening of gullies during erosive processes (Vanderkerckhove et al., 2001; Malik, 2008). The aim of the study is

1. to verify the use of dendrogeomorphic methods to analyze processes on a selected alluvial fan in the Moravskoslezské Beskydy Mts.,
2. to reconstruct the frequency and character of the processes, and
3. to analyze the meteorological conditions leading to these processes.

2. Locality

The study area is in the eastern Moravskoslezské Beskydy Mts. (49°35′17″N; 18°41′45″E). The selected alluvial fan is located on the right bank of the Kopytná River, with its source basin on the slope under Mt. Kozubová (981 m a.s.l.); the source zone is found at an elevation of 590 m a.s.l. with the very top of the fan at an elevation of 490 m a.s.l. From a geological point of view, the Moravskoslezské Beskydy Mts. represent a young nappe mountain range composed of flysch deposits gently inclined (10–20°) to the SSE. The source basin of the fan is predominantly composed of Istebna Formation composites (thickly bedded flysch with prevailing sandstones and conglomerates) passing into the middle member of the Godula Formation (thick layers of sandstones and conglomerates) in the upper part of the basin. These two rock formations are separated by a fault. (Menčík et al., 1983).

The accumulation body at the mouth of the source basin is composed of three overlapping fans. Forming the western lower part of the whole complex, the first alluvial fan is ~60 m wide, currently inactive and overgrown by meadow grasses (the middle fan). The second alluvial fan forms the highest part of the complex (the highest fan). It overlaps the upper half of the middle fan as well as the edge of a ~3-m-high fluvial terrace. This fan, void of surface accumulation, is partially covered by mature forest. It is cut from top to bottom by a 30-m-long gully of variable width (0.5–2.5m) and depth (0.2–1.7m). The bottom of the gully is very uneven and characterized by four distinctive steps up to 1.3 m high. In one place the gully cuts down to bedrock. Moreover, the forefront of the alluvial fan is cut by a further gully that is 8 m long and 0.5 m deep at maximum. The youngest alluvial fan has formed at the mouth of the upper, larger gully (the lowest fan). It is ~40 m wide and overlaps the middle alluvial fan on its western side. This fan, including the mostly active central part where fresh material is accumulating, is covered by a mature forest of *Picea abies*. The location and geomorphic features of the alluvial fan complex are shown in Fig. 1.

3. Methods

3.1 Fieldwork

The alluvial fans complex and its wider surroundings were mapped at a scale of 1:500 focusing on the accumulation (fans) and erosion (gullies) features; selected trees affected by accumulation activity on the active part of the alluvial fan (the lowest fan) were sampled using a Pressler increment borer. Two increment cores were taken from each tree: one in the direction of processes and the other from the opposite direction. The sampling height was selected based on the way a specific tree was affected. Trees whose stem bases had been buried were sampled as low down as possible, whereas sporadically scarred or tilting trees were sampled at the height of damage or maximum stem flexion. Exposed roots growing across gullies were sampled by cutting cross sections: this also required recording the exact position of a sample (height above the gully bottom, depth from the alluvial fan surface, original orientation of the sample and its distance from the gully edge). Emphasis was placed on sampling near the centre of the gully. A total of 30 increment cores and 12 cross-sections were taken from the trees of *Picea abies*. In order to determine "common" growth conditions, 20 more increment cores were taken from trees unaffected by geomorphological processes (growing in the stable part of the slope at ~100 m distance from the fans complex) and a reference chronology was compiled (Cook and Kairiukstis, 1990) (Fig. 3c).

Samples for sedimentological analyses were taken from representative (both naturally and artificially) exposed areas. About 500 g of material of < 20 mm diameter were taken in order to carry out grain-size analysis and 50 clasts of 20–100 mm were taken to evaluate clast shape and roundness.

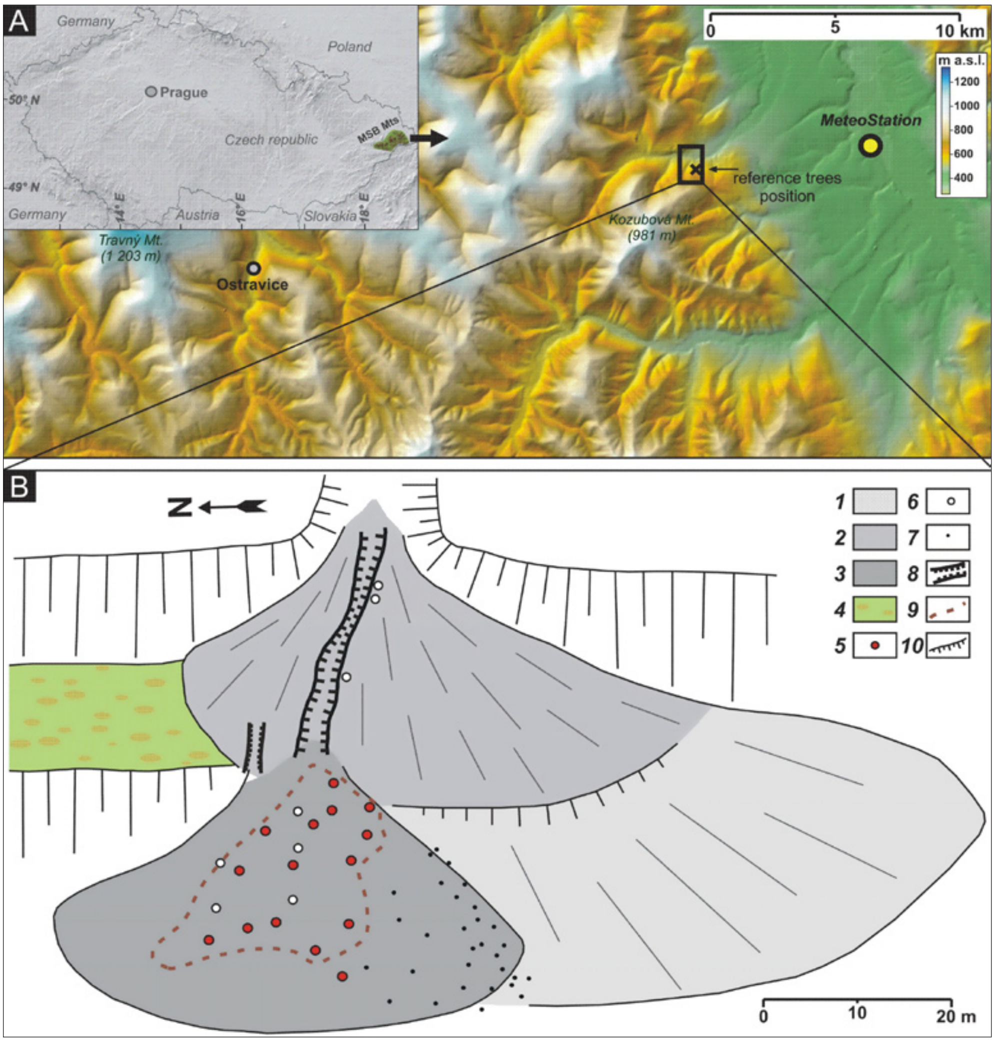

Fig. 1: A – Location of the study area (in the Czech Republic. B – geomorphological features (1 – middle fan surface 2 – highest fan surface, 3 – lowest fan surface, 4 – fluvial terrace, 5 – sampled tree, 6 – sampling site for sedimentological analysis, 7 – unsampled trees growing outside the active area of the fan, 8 – gully, 9 – active zone within the fan surface, 10 – fluvial terrace)

3.2 Laboratory approach

Samples intended for dendrogeomorphic analysis were processed in compliance with standard procedures described by e.g. Stoffel and Bollschweiler, 2008. The samples were left to dry, inserted into stabilization grooves, smoothed and polished. Tree-rings were counted and tree-ring widths were measured using the TimeTable measuring device and the PAST4 programme (V.I.A.S., 2005). False or missing tree-rings, identified by comparison with the reference chronology tree-ring series from the 20 unaffected trees, were subsequently corrected using the cross-dating method.

Granulometric analysis was carried out by means of the wet sieving method (sieves: 10,000, 5,000, 2,000, 630, 200, 63, and 20 μm) and evaluated in the Gradistat 4.0 programme (Blott and Pye, 2001). Clast roundness, assessed subjectively according to a grade scale introduced by Krumbein (1941) and modified by Powers (1953), was expressed by means of the RA index (percentage of angular and very angular clasts in a sample). Individual clast axes (a, b, c) were measured with an accuracy of 1 mm. The clast shape was expressed by means of the C40 index (percentage of clasts with c/a axial ratios ≤ 0.4; Sneed and Folk, 1958).

3.3 Identification and reconstruction of geomorphological events

The effect on increment cores of geomorphological processes on tree growth was identified based on the following visual features (Fig. 2):

a) (Figs. 2c, 3b), abrupt growth suppression (response of a stressed tree to buried stem base or mechanical wounds to tree-stem surface) (Fig. 2c),
b) abrupt growth release (response to stem damage in a remoter part of its circumference) (Figs. 2d, 3a),
c) compression wood in coniferous trees (response to tilting) (Fig. 2a),

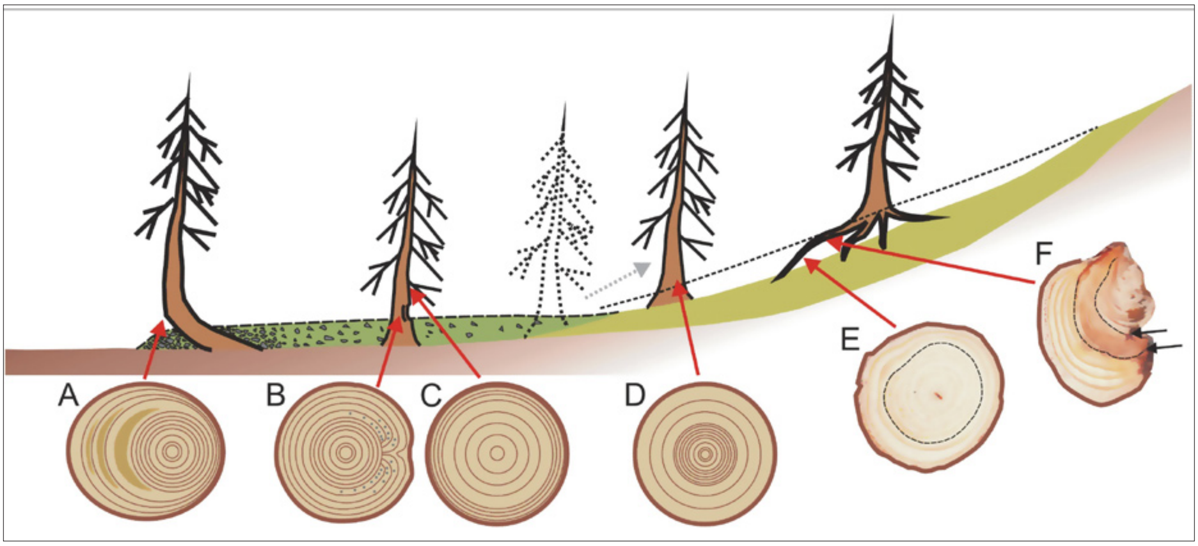

Fig. 2: Tree growth response to accumulation and erosive processes on the alluvial fan. A – reaction wood formation as a response to tree tilting, B – formation of scars and traumatic resin ducts due to stem damage, C – sharp narrowing of tree-rings due to stem base burial, D – abrupt widening of rings due to elimination of adjacent trees (dotted outline), E – change in the structure of tree-root wood after exposure (dashed line = surface erosion), F – formation of scars on roots following damage (black arrows = ring boundaries dating location of damage)

d) formation of tangential rows of traumatic resin ducts – TRDs (in response to mechanical wounding caused by a geomorphological process) (Fig. 2b),
e) scar formation (in response to tree surface wounding) (Fig. 2b).

In order to be sure that the identified tree-ring width changes resulted from the impact of geomorphological process, only severe growth suppression (55%) and strong growth acceleration (200%) were considered plausible evidence (Schweingruber et al., 1990).

Moreover, only growth changes, which significantly differ from reference chronology variations are considered as results of geomorphological process impacts (Fig. 3).

Erosive events in gullies were identified by means of root cross-sections. Once exposed, the roots of coniferous trees respond almost immediately by a change in the size of new cells. An exposed root produces up to 50% smaller cells, as compared with cells of an unexposed root (Gärtner, 2007; Malik, 2008) (Fig. 2e). Root exposure also makes possible identification of early wood and late wood within a tree-ring. Likewise, erosive events may induce root wounding followed by scar formation (Fig. 2f). Anatomical changes in cell size were analyzed using a binocular microscope.

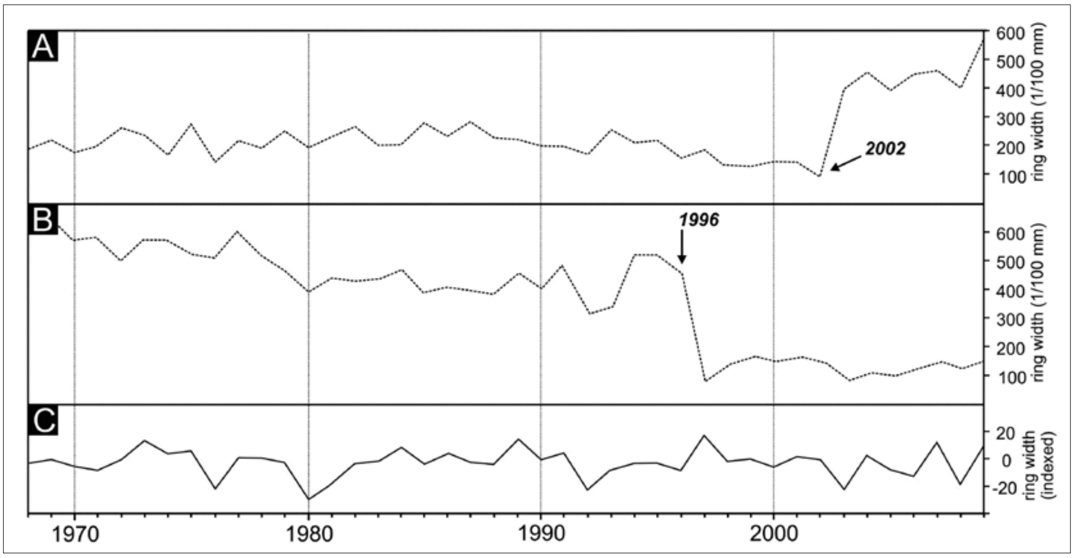

Fig. 3: Comparison of increment curves from disturbed trees with reference chronology. A – abrupt growth release, B – abrupt growth suppression, C – reference chronology

Reconstruction of erosive and accumulation events was derived from a minimum number of samples with respect to their spatial position (Bollschweiler and Stoffel, 2010). Years in which particular geomorphological processes originated were taken as those indicated by at least two samples whose mutual position related logically to the geomorphological event. Years indicated by only one sample were recorded as probable events.

Meteorological data necessary for the analysis of major influences on the activity of geomorphological processes were obtained from the Jablunkov-Návsí (380 m a.s.l.) meteorological station ~6 km from the fan (Fig. 1).

4. Results

Number of trees, samples, dated disturbances and reference chronology

Trees that grow in the largely active zone of the lowest alluvial fan were sampled in order to assess the distribution of accumulation processes on the fan. The oldest sampled tree was 55 years old, whereas the youngest was 43 years. Average age was 49.2 years. The average age of the surrounding forest is ~100 years. This is why the forest on the fan complex was probably "managed". The increment cores helped to identify and date 51 growth disturbances related to accumulation processes on the alluvial fan. Major reactions of trees included abrupt growth suppression (41%) compression wood formation (19%), traumatic resin ducts (TRD) (16%), scars (14%) and abrupt growth release (10%). All abrasion scars were oriented in the geomorphological process direction, and occurred at heights up to 20 cm above the ground. Absolute values of the number of dated accumulation events in individual years are shown in Table 1. All identified disturbances were compared with reference chronology. Only those that did not correspond with ring width changes in reference trees were considered as result of geomorphological process impact. Climatically driven narrow rings (pointer years) funded from reference chronology were 1976, 1980, 1992 and 2003. All these years correspond with the findings of Čermák et al. (2010) from the near Moravskoslezské Beskydy Mts.

Erosive events in the gullies were dated using cross-sections taken from exposed roots. The oldest root showed 48 rings, whereas the youngest one 15 rings. Average root age was 32.6 years. Attention was paid to root exposure as indicated by abrupt reduction in cell size and root damage connected with scar formation. Detailed analysis of cross-section surfaces supplied 18 dates for erosive events. Root exposure accompanied by anatomical changes in cell size was dated in 67% of all samples. Root damage followed by scar formation was dated in 33% of all samples. Absolute values of the number of erosive events in individual years are given in Table 2.

Reconstructed accumulation events

Assessment of a minimum number of trees showing growth disturbances within the same year enabled reconstruction of a total of 13 accumulation events on

Year	Growth suppression	Growth release	Reaction wood	TRD	Scar	Total	Trees
2008		1				**1**	1
2005				1		**1**	1
2002	4		1	1		**6**	4
2000	2					**2**	2
1996	2					**2**	1
1993	5	3				**8**	7
1988	3			1		**4**	2
1982	3				1	**4**	3
1977		1	3		1	**5**	5
1975	1		1			**2**	1
1974			1			**1**	1
1972			1	4	3	**8**	3
1970	1		3	1	2	**7**	4
total	21	5	10	8	7		

Tab. 1: Number of identified growth disturbances and affected trees in individual years in the accumulation area on the alluvial fan.

Year	Root exposure	Scar	Total
2008	2	2	**4**
2005	1	1	**2**
2002	1	1	**2**
1996	3	1	**4**
1993	1	1	**2**
1977	2		**2**
1972	2		**2**
total	12	6	

Tab. 2: Number of identified growth disturbances caused by erosive processes on roots in a gully

the lowest alluvial fan in the last 45 years (Fig. 4a). According to the criteria we adopted, eight of these events can be considered 'real', while five events can be considered 'probable'. Intensive accumulation-based evolution of the alluvial fan falls within the period of 1970–1977 within which five events were dated. Sporadic events characterize the period of 1978–1999 when only four events took place. The second period of marked accumulation activity started in 2000, continued up to 2008 and comprised four events.

The position of all sampled tress was indicated on a geomorphological map (Fig. 5). Positions of trees that experienced a growth disturbance within a single year made it possible to reconstruct the spatial extent of accumulation events on the active part of the alluvial fan. The spatial extent of four major events was reconstructed based on four affected trees. The oldest event, affecting four trees on the central part of the fan, took place in 1970. The maximum reach of accumulation sediments was ~20 m from the gully mouth. A different behaviour pattern was identified in connection with the 1977 event reconstructed from the positions of five trees. Similar to the 1970 event, only trees in the central part of the alluvial fan were affected. However, the accumulation itself changed direction heading towards the northern end of the fan. The 1993 event affected the highest number of trees (seven) within the dating period. The accumulation parted into two branches, each occupying the opposite margin of the active zone. The northern branch is almost 30 m long and the southern branch is 10 m long. The last reconstructed event, which occurred in 2002, affected four trees and its course resembled the character of the 1993 northern branch.

Reconstructed erosive events

Similar to accumulation events, the determination of erosive event years is based on the minimum number of samples recording growth disturbance. The studied period revealed seven events, which caused deepening in part of the gully (Fig. 4b). All the events can be considered 'real' since they are replicated on the required number of samples. At the same time, all dated erosive events correspond to real or at least probable accumulation events. The oldest events date back to 1972 and 1977 followed by a long break of 15 years void of erosive activities. In the period between 1993 and 2008, five events occurred (1993, 1996, 2002, 2005, and 2008).

A careful record of the positions of sampled roots enabled reconstruction of the evolution of the depth and length of both gullies (Fig. 6). Initial deepening in the upper

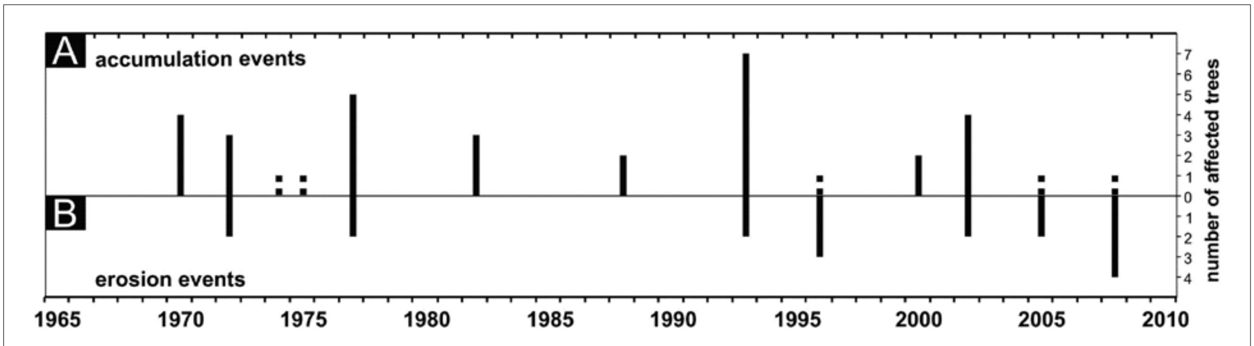

Fig. 4: Accumulation (A) and erosive (B) events confirmed by dendrogeomorphic study with regard to the number of affected trees. Continuous line = guaranteed event, dashed line = probable event (reconstruction based on the dating of a single sample)

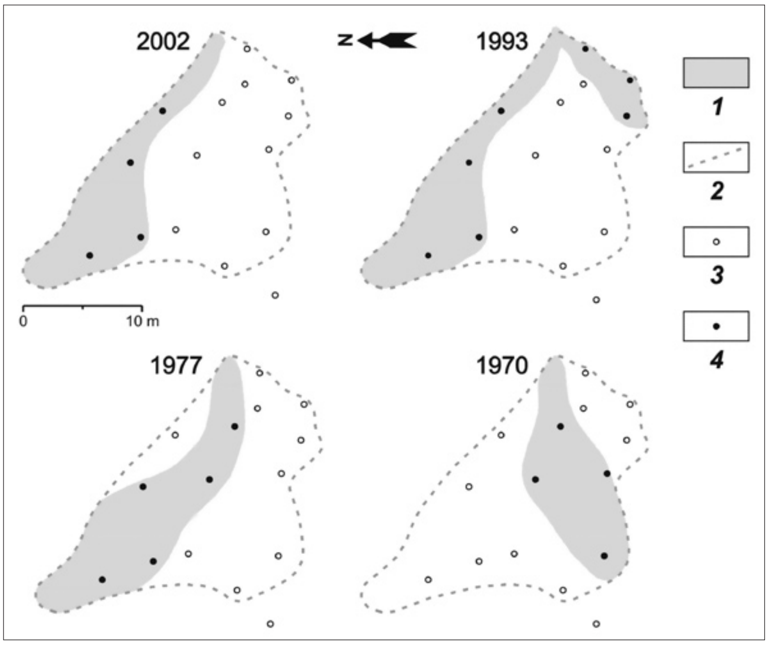

Fig. 5: Spatial reconstruction of the largest accumulation dendrogeomorphically confirmed events (1 – accumulation-affected area, 2 – active zone boundary defining the youngest formation period of the alluvial fan, 3 – sampled tree, 4 – sampled tree displaying growth disturbance in a given year)

end of the longer gully confirmed dendrogeomorphically took place in 1972. Subsequently, the deepening continued progressively into lower parts of the gully. Samples taken in the upper part of the gully helped to date several erosive events that further damaged exposed roots. Similar evolution was identified in the shorter gully where the deepening started at its upper end and progressed to its mouth.

Sedimentological analysis of material

Granulometric analysis was carried out using four samples taken from the most active part of the lowest alluvial fan and two samples taken from an outcrop at the highest fan. The results are presented in Fig. 7a; they show a clear difference between the two groups of samples. The material of contemporary

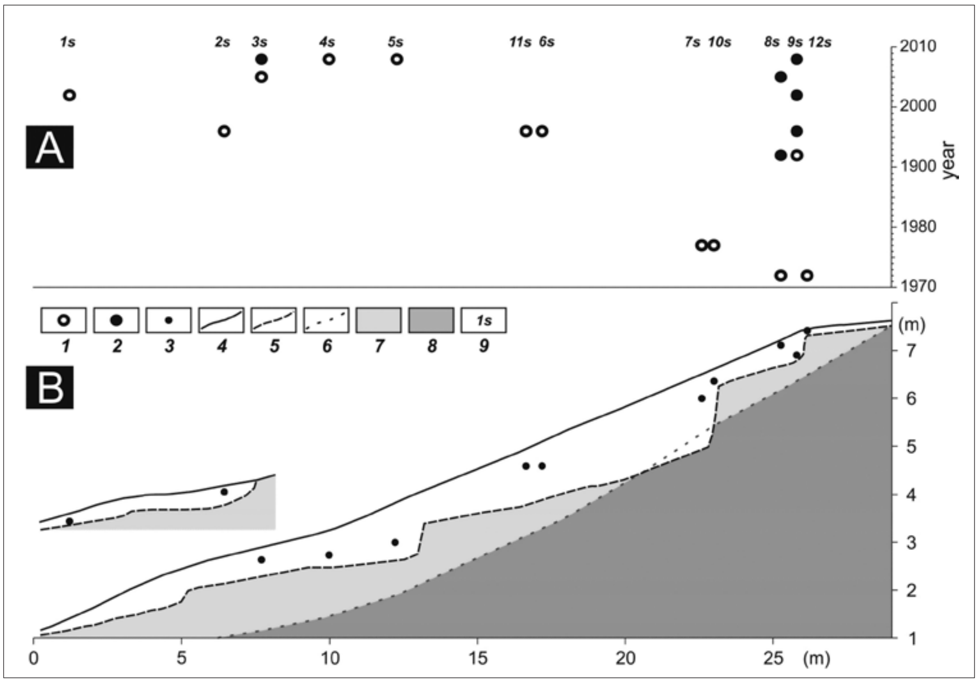

Fig. 6: A – Spatio-temporal evolution of longitudinal and vertical gully deepening, B – longitudinal profile of gullies including the position of samples (1 – root exposure, 2 – root damage, 3 – root position within gullies, 4 – current surface of the alluvial fan, 5 – gully bottoms, 6 – assumed boundary between alluvial fan material and bedrock, 7 – alluvial fan material, 8 – bedrock, 9 – root sample indication)

accumulation processes is constituted predominantly of slightly sorted sand and gravel in a matrix of mud. The well-sorted material from the older alluvial fan is characterized by equal amounts of gravel, mud, and sand. Clast shape and roundness analysis was performed based on a maximum representative sample of the material of the highest and lowest alluvial fan formations. Fig. 7b shows that the clast shape of the two samples is similar. A more significant difference is found with respect to clast roundness since the material of contemporary accumulation processes is approximately twice as rounded as the material from the highest alluvial fan. There are greater differences between material sorting and medium-size grains of the two types of clast (Tab. 3).

	RA	C_{40}	M_G	s_G
old fan	36	74	112	15.6
young fan	18	69	386	6.1

Tab. 3: Average values of roundness (RA), shape (C_{40}), medium size (M_G) and sorting (σ_G) of the material from the oldest and youngest alluvial fans

The analysis of meteorological events, potentially triggering processes on the alluvial fan (Fig. 8), focused on maximum total amounts of daily precipitation (mm/24h), maximum height (cm) of snow cover at the end of spring (March, April) and thawing index (°C) defined as the difference between average April and May temperatures (Zielonka et al., 2008). Two groups of processes can be distinguished. The first group involves processes caused by extreme short-term precipitation events (more than 100 mm/24h), based on the results, these took place in 1970, 1972, 1974, 1982, 1996, 2000 and 2002. The other group, defined as years in which the potential causative mechanism was sudden thawing of large quantities of snow, includes the years 1977, 1988, 1993 or 1996.

5. Discussion

Using dendrogeomorphic methods, accumulation and erosive activities of geomorphic processes were analyzed on a selected alluvial fans complex at the foot of the northern slope of Mt. Kozubová. A total of 30 increment cores from 15 *Picea abies* trees were used to reconstruct 13 accumulation events that had taken place on the fan (five of them considered as probable events). The analysis of 12 cross-sections of exposed roots growing across a deepened gully revealed seven erosive events. It is important to observe that dendrogeomorphic analyses inform only of episodes that occurred, but it is not possible to reconstruct which of the episodes was more energetic and extreme. For this reason, it is necessary that all dated events are considered only as events confirmed by the dendrogeomorphic study.

Some of the events (15) showed on one tree only and therefore can be considered as probable. Moreover, some events may not have been detected at all owing to an insufficient number of trees. This is a common problem in many dendrogeomorphic studies (Gottesfeld and Gottesfeld, 1990; Strunk, 1997; Bollschweiler

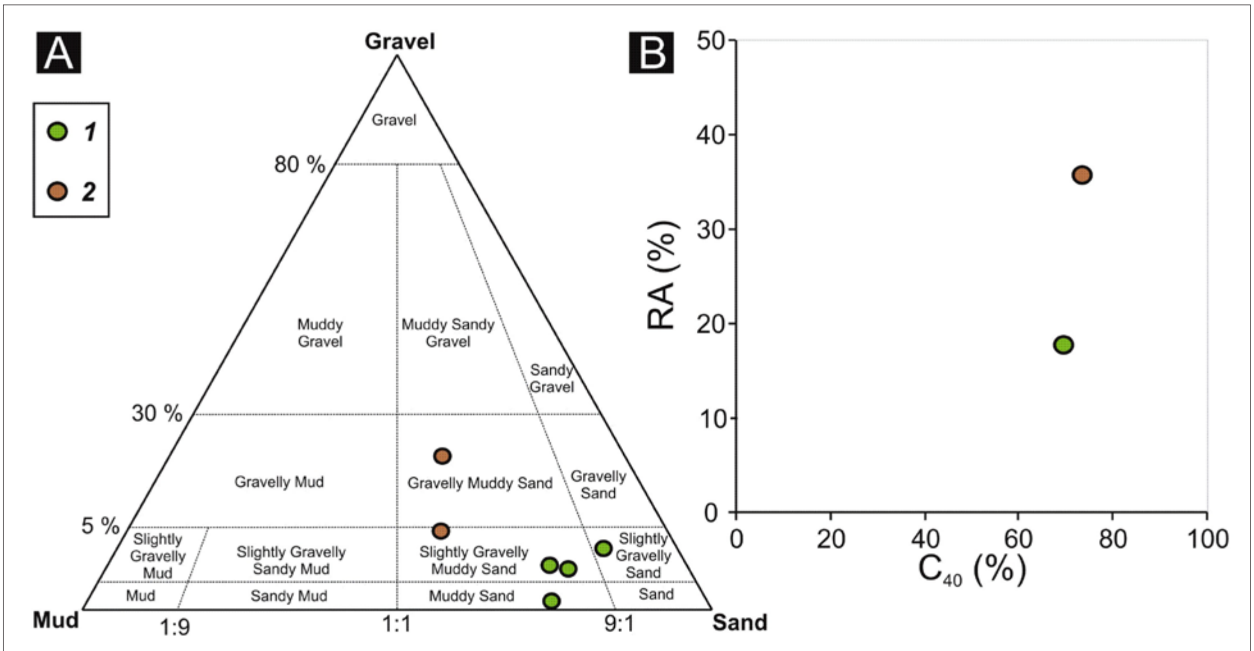

Fig. 7: Sedimentological characteristics of the material of the lowest (1) and the highest alluvial fan (2) A – results of grain-size analysis, B – relation between class roundness (RA) and clast shape (C40)

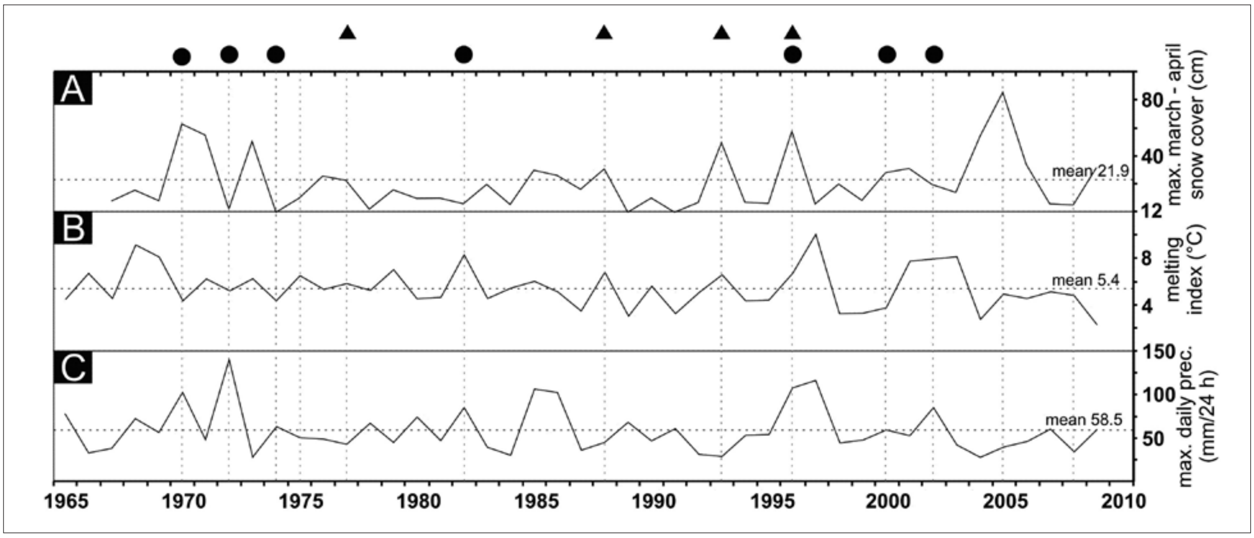

Fig. 8: Comparison of the occurrence of dated processes using selected meteorological indices. A – maximum snow cover thickness in March and April, B – melting index (difference between average temperatures in April and May, Zielonka et al., 2008), C – maximum daily total precipitation amount per year (black spots – event years with above-average daily precipitation occurrence; black triangles – event years with above-average melting index combined with snow cover occurrence)

et al., 2008; Stoffel and Bollschweiler, 2008, 2009; Zielonka et al., 2008; Szymczak et al., 2010). As a result, the number of reconstructed accumulation events can only be considered as a minimum value (Stoffel and Bollschweiler, 2009). Likewise, some of the erosion-based gully-deepening events may not have been detected owing to the insufficient root coverage of the gully.

The results show that 41% of 51 dated tree-growth disturbances in the accumulation area are represented by the sharp narrowing of rings. This finding corresponds to a typical response of trees whose base has been partially buried (Schweingruber, 1996; Stoffel and Bollschweiler, 2008). All dated growth suppressions were strong (min. 55%) and significantly differed from reference chronology fluctuations. Dated growth disturbances in increment cores could therefore have originated as a consequence of accumulation processes. Moreover, other processes (rockfall or snow avalanches) were not identified in the study area. The scarcity of scars and abrupt widening of rings (only 14 cases or 10% of the sample) may have been due to low flow activity resulting in insignificant or no damage to trees. No signs of forest measures were observed in the surroundings of the studied locality that could have been a potential cause to the suppressed or release growth.

What is interesting is the temporal occurrence of reaction wood. All trees (except one) containing reaction wood were tilted in 1977 at the latest. There are two possible explanations: one is that older accumulation processes were of a magnitude big enough to tilt some of the trees; this hypothesis is supported by the spatial distribution of affected trees; the other and more likely explanation is that the volume of the accumulated material differed only negligibly from younger events but trees there growing were smaller and lesser force was sufficient to tilt the trees (Schweingruber, 1996).

Gully-root analysis suggests progressive deepening from the upper to the lower end of the gully. Similar findings were recorded by Malik (2008) concerning several gullies. In a number of cases, however, the chosen analyzed roots were at a variable vertical distance below the alluvial fan surface. Therefore, the deepening may not have propagated in a downhill direction but could have occurred evenly throughout the whole gully. This would also explain the later exposure of roots in the lower part of the gully (e.g. samples 4s and 5s; Fig. 6a) in comparison with the upper gully roots growing relatively deeply below the alluvial fan's surface. The present gully bottom has a very uneven profile with several steps. These could have originated as a consequence of backward erosion induced by a series of base level occurrences at the bottom of the gully. Currently, the base level is formed by boulders (> 20 cm), which accumulated at the gully bottom after fine particle fractions had been washed out.

In the case of meteorological events such as precipitation or snow-thaw it is impossible to determine which factor prevailed since both of them occurred at above-average intensity. The year in question is 1996. On the other hand, for some years, neither precipitation nor spring thawing may be implicated (e.g. 1975 and 2008) since, due to the meteorological station's distance from the fans and differing geographical conditions, these factors should only be considered as possible agents, as suggested by e.g. Szymczak et al. (2010). If this is the case, the causative factor could have been an event that the meteorological station failed to record.

The moderate character of the accumulation processes indicated by the identified growth disturbances was verified by sedimentological analyses. Medium grain size (M_G = 3.8 mm), material sorting (σ_G = 6.1) and maximum clast size (~40 mm) indicate that the accumulation processes occurring on the alluvial fan are not debris flows but single fluvial accumulations of fine particle material. On the other hand, unsorted and gently round material containing larger clasts (< 30 cm) from the material of the older alluvial fan points to the accumulation activity on the debris flows.

Based on these analyses, we propose that the evolution of the alluvial fan has been the result of a wide number of processes. The highest alluvial fan most likely originated as a result of accumulation due to debris flow activity, the question remains when? The present morphology of the alluvial fan surface shows no traces of fresh debris flow activity and the dating of alluvial fan material using absolute dating was impossible. Nevertheless, one isolated alluvial fan of a similar extent has been dated in the Moravskoslezské Beskydy Mts. to the Atlantic period (Šilhán and Pánek, 2009). So, one of tentative possibilities is that this alluvial fan is of a similar age. However, it can originate from or just after the "little ice age" maximum as well.

The change in processes on the alluvial fan (fluctuating from degradation to aggradation and back) is most likely connected to a change in environmental conditions of the source basin. At present, the basin is fully covered by forest and therefore is not a locality for potential debris flows with contemporary erosion and accumulation processes on the fan driven by flowing water often related to extreme precipitation events. Under such conditions debris flows still originate in the Moravskoslezské Beskydy Mts. (e.g. 1972, 1996 and 2002) (Šilhán and Pánek, 2010), but almost exclusively in morphometrically more extreme areas.

6. Conclusion

Alluvial fans are landforms whose origin and evolution are affected by a wide range of processes. Where archival records are lacking, dendrogeomorphic methods represent the most accurate dating methods for processes that may be hundreds of years old. Use of a dendrogeomorphic approach helped us reconstruct processes on an alluvial fan in the eastern part of the Moravskoslezské Beskydy Mts. A total of 13 accumulation events were identified by means of growth disturbance analysis performed on 30 increment cores. In addition, analysis of anatomical changes in exposed roots revealed seven erosive events in a gully crossing the fan. A combination of the dated accumulation events and analysis of tree positions enabled spatial reconstruction of accumulation events with these showing four basic accumulation patterns on an active part of the fan.

The different types of growth disturbance identified from the increment cores and sedimentological analysis of the fan material show that present processes on the fan are a combination of fluvial erosive and accumulation processes.

Analysis of data from the nearest meteorological station indicated two basic factors influencing the origin of the modelling processes on the fan's surface: the first factor - total short-term precipitation amounts including values over 100 mm/24h – occurred in events during 1972 or 1996; the second factor – sudden thawing of high snow cover in spring months – was connected to events in 1977 and 1993.

The trees on the lowest alluvial fan provide a natural record of a marked change in geomorphological processes that took place on the fan in the past and prove that its contemporary evolution is exclusively related to extreme meteorological events.

Acknowledgement

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STRUCTURE AND GENESIS OF THE QUATERNARY FILLING OF THE SLAVÍČ RIVER VALLEY (MORAVSKOSLEZSKÉ BESKYDY MTS., CZECH REPUBLIC)

Václav ŠKARPICH, Jan HRADECKÝ, Petr TÁBOŘÍK

Abstract

The present form of valleys is a result of complex land cover, geological and climatic conditions, which affect geomorphological processes of channel-floodplain (dis)continuum. The main aim of this paper is to present the characteristics of valley fill deposits in the Slavíč River basin with the use of fluvial geomorphological mapping, electrical resistivity tomography (ERT) and outcrop analysis. The ERT method was used to determine the structure of valley fill deposits. The lithofacial analysis was made to determine sets of fluvial formations. Two leading lithofacies were distinguished in the studied terrace outcrop: Gh facies, which were interpreted as fluvial forms influenced by deposits from debris flow material, and Gm facies, which were interpreted as fluvial forms with massive gravel transport.

Shrnutí

Struktura a geneze čtvrtohorní údolní výplně vodního toku Slavíč (Moravskoslezské Beskydy, Česká republika)

Současné formy reliéfu údolních den jsou výsledkem působení krajinného krytu, geologických a klimatických poměrů na geomorfologické procesy koryto-nivního (dis)kontinua. Hlavním cílem tohoto příspěvku je výzkum údolních výplní v povodí vodního toku Slavíč s využitím fluviálně geomorfologického mapování, elektrické odporové tomografie (ERT) a analýzy kopaných sond. Metoda ERT elektrické odporové tomografie přinesla informace o struktuře údolních výplní. Litofaciální analýza přinesla základní obraz o jednotlivých sedimentárních formacích. V odkryvu byly odlišeny dvě hlavní facie: Gh, kterou interpretujeme jako fluviální formaci ovlivněnou materiálem blokovobahenních proudů a Gm, kterou interpretujeme jako fluviální formaci s ovlivněnou masivním transportem štěrkové frakce.

Keywords: *electrical resistivity tomography, sediments, terrace, valley fill deposits, Slavíč River, Moravskoslezské Beskydy Mts., Czech Republic*

1. Introduction

Together with the Morávka River, the Slavíč River is one of the sources of the Morávka water reservoir (Fig. 1). At the mouth of the reservoir, the stream has created a very wide valley filled with Quaternary deposits. The valley bottom is built of alluvial fans, debris flow accumulations and multi-level terraces. Valley fill deposits of the Outer Western Carpathians belong to insufficiently investigated landforms (Šilhán, Pánek, 2009; Pánek, Hradecký, 2000). The distribution and type of these Quaternary accumulations shed light on the geoecological conditions of the past (Schrott et al., 2003). The main aim of the research is to investigate the valley fill thickness and genesis of sediments in the Slavíč River basin. The study of the sediment genetic type and deposit thickness can help to specify dominant processes between the slope and floodplain systems, which are important for landscape development and sediment budget recognition (Schrott et al. 2003; Dietrich, Dunne, 1978).

2. Regional setting

The local relief is characterized by a highly dissected basin with an average slope gradient ranging from 15° to 35°. From the geological point of view (Fig. 2), the basin is built up of the Silesian unit of the Outer Carpathian Group of nappes. Strictly speaking, it concerns the monoclinal structure of the Godula Sub-

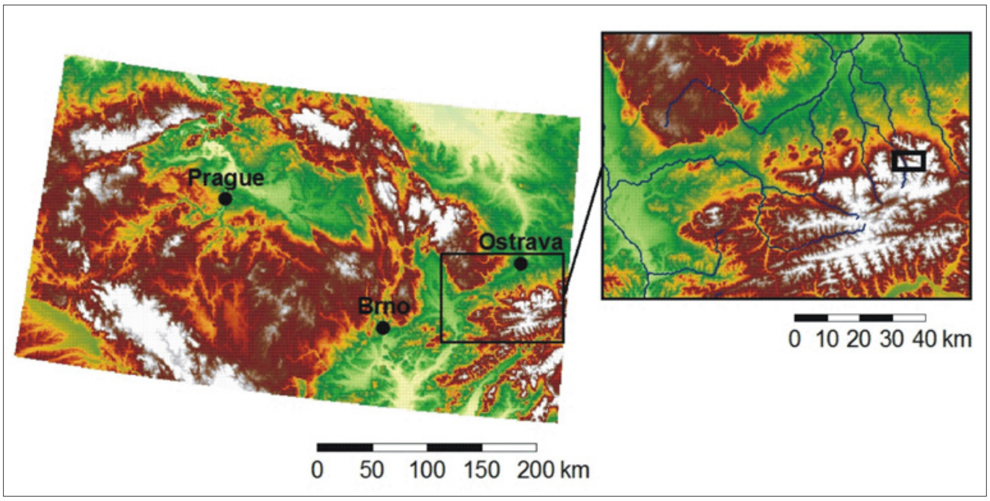

Fig. 1: Position of the studied locality (in the rectangle)

Nappe built by thick-bedded glauconitic sandstones (Middle Cretaceous) of Middle Godula Member flysch overlying thin-bedded glauconitic sandstones and shales (Middle Cretaceous) of Lower Godula Member fine-rhythmic flysch. The upper part of the basin is a contact zone between the Upper and Middle Members of the Godula Formation (Middle Cretaceous) (Menčík, Tyráček, 1985).

The terrace outcrop under study (~6 m in height) is located on the left bank of the Slavíč R. lower Basin (Fig. 1), relatively close to the mouth of the Morávka water reservoir. The valley fill deposits are built of fluvial sediments, flood loams and gravels of the Holocene-Vistulian age and deluvial loamy stone debris or stone debris of the Holocene-Pleistocene age (Menčík, Tyráček, 1985; Menčík et al. 1983).

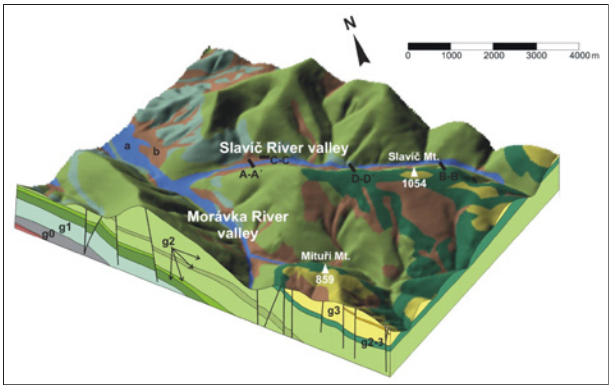

Fig. 2: Scheme of the geological structure of the studied area: g0 – Lhoty Formation, g1 – Lower Godula Member, g2 – Middle Godula Member, g2–3 – Middle-upper Godula Member, g3 – Upper Godula Member, a – fluvial deposits, b – colluvial and proluvial deposits or slope deformations

3. Methods

The valley fill deposits were investigated using electrical resistivity tomography. The method is based on the calculation of measured subsurface apparent resistivity (Griffiths, Barker, 1993; Drahor et al., 2006). The Wenner-Alpha electrode array was selected with regard to the geological condition of the sub-horizontal and horizontal deposition of valley sediments. The method has a good resolution where the resistivity would change in the vertical direction. Of all commonly used ERT methods, it is least sensitive to very near subsurface resistivity (Griffiths, Barker, 1993; Loke, 1996). Making a compromise between the best resolution along with the hypothetical depth of measured ERT profile and the thickness of valley fill deposits, the spacing of electrodes was chosen at 1.5 and 2 meters.

Samples taken for the grain-size analysis from the respective sedimentary layers were sieved by using the Fritsch ANALYSETTE 3PRO with 20, 63, 200, 630, 2,000, 5,000 and 10,000 μm diameter of sieves. Data obtained from the sieving were analysed by using the Autosieve software. The results were interpreted using the GRADISTAT programme, a Microsoft Office Excel extension (Blott, Pye, 2001).

A set of fifty clasts was taken from each layer in order to perform an analysis of particle shape and roundness along with a laboratory analysis. Particle shape analysis consists in the measurement of three perpendicular particle axes – a – longest, b – intermediate and c – shortest – that define the three-dimensional shape of particles (Bunte, Abt, 2001). The mutual relation of axes indicates elongation (b/a ratio), flatness (c/b ratio), and compactness (c/a ratio) (Scally, Owens, 2005).

The shape of particles was interpreted using TRI-PLOT (triangular diagram petting spreadsheet), which represents the relation between the crossing of axes

(Sneed, Folk, 1958) described above. An important characteristic reflecting particle shape is C_{40} index expressing the following percentage:

$$C_{40} = c/a \leq 0.4 \, [\%] \qquad (1)$$

Analysis developed by Krumbein (1941) was used for the assessment of pebble roundness. It is based on the visual estimation of particle roundness using six classes: VA – very angular, A – angular, SA – sub-angular, SR – sub-rounded, R – rounded, WR – well rounded. This analysis is subjective and the results are therefore dependent on experience of the person performing the sampling. Pebble roundness is described by the RA index, which can be expressed as follows:

$$RA = (VA + A) / \text{number of clasts} \, [\%] \qquad (2)$$

where VA is a number of very angular clasts and A is a number of angular clasts (Graham, Midgeley, 2000).

The interaction between particle shape and particle roundness was visualized using a point graph with the values of RA and C_{40} indices and the trend of the RA / C_{40} index changing with the depth.

In layers of 0.3 m > x > 1.3 m and 4.7 m > x > 5.4 m, where x is vertical distance from the terrace surface in situ, the clast orientation was measured with the use of the longest a axis of twenty clasts. In other layer series, the clast orientation was not measured for reasons given by the absence of matrix and discrete gravel fill. The data were evaluated in the StereoNett v. 2.46 programme and GEOrient 9.2 software.

Sets of fluvial formations were determined by means of lithofacial analysis proposed by Miall (2006). The complex analysis of sediment budget in the basin was based on the fluvial geomorphological mapping using 1:10 000 topographic maps and aerial photos (Fig. 3 – see cover p. 2)

4. Results

The ERT A-A' profile (across the valley) showed relatively high resistivity values (> 1,200 Ωm) within the floodplain sediment deposits (Fig. 4). This is attributed to air-filled space between the particles. The boundary between sediment deposits and bedrock built by thin-bedded flysch represents an area of lower resistivity values (< 600 Ωm). Two structures of vertical character occurring in the central part of the profile are characterized by lower resistivity values (< 100 Ωm). Lower values of these structures, identified as tectonic lines predisposing the valley course, are caused by water that occurs along them. In the area of the left slope (between the 270th to the 302nd m of the profile), we can identify a relatively thick layer of colluvial sediments which is characterized by very high resistivity values (> 2,000 Ωm). These values are probably caused by deposits of dry character and, similarly to the fluvial deposits of higher situated river terraces, by air-filled space between the particles.

ERT measurement revealed conditions in the upper parts of the Slavíč River basin. Using the B-B' profile (Fig. 5a), relatively high resistivity values (> 1,000 Ωm) were measured in a part of valley-fill deposits (between the 50th and 92nd m of the

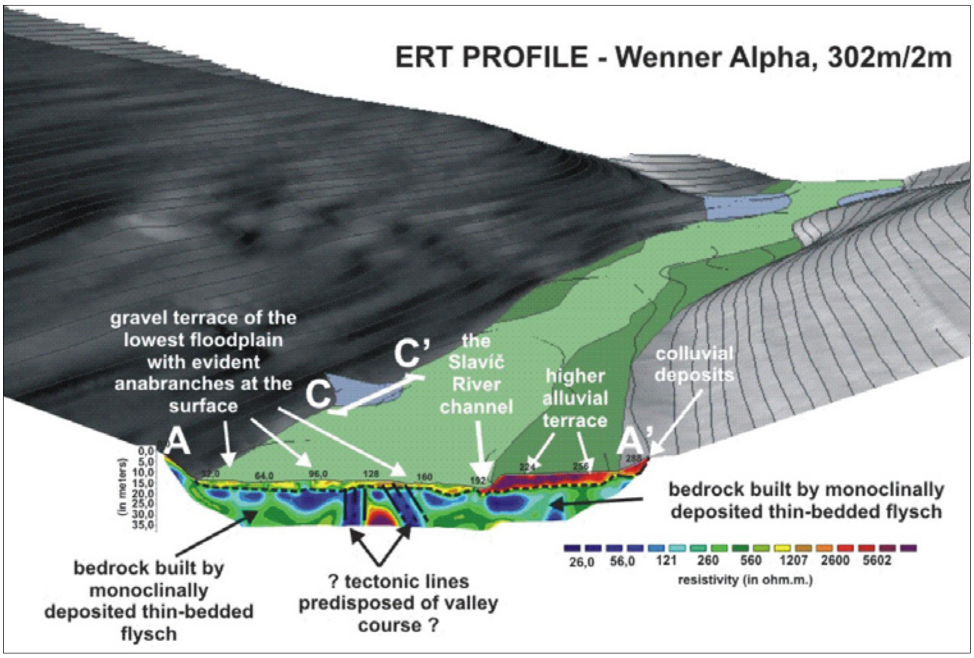

Fig. 4: ERT A-A' profile across the Slavíč River valley (for profile localization see Fig. 2)

profile). In this case, high resistivity values were also caused by air-filled space between the particles since the accumulation is predominantly built of gravel. The grain-size distribution of gravel/sand/mud is 83.5/15.2/1.3% respectively (after Blott, Pye, 2001). The RA index (28%) shows a large volume of round particles, while the C_{40} index value is 70%. An analogous situation to this ERT profile was observed between the 32nd and 40th m of the profile: higher resistivity values (> 1,000 Ωm) are explained by air-filled space between the sediment accumulation particles.

The central and bottom parts of the profile are characterized by areas of resistivity ranging from 20 to 100 Ωm and from 100 to 1,400 Ωm. This can be caused by a sub-horizontally bedded clay stone formation underlain by a sandstone formation. In the profile between the 40th and the 50th m (Slavíč River channel) and between the 92nd and 100th m, the area of resistivity ranging from 20 to 100 Ωm is interpreted as a sub-horizontally bedded clay stone formation in contact with the surface. This fact was observed during the field research where bedrock is visible on the surface and in the channel. In the area of adjacent slopes (0–32nd m and 100th–126th m) we can identify a layer of relatively thick colluvial sediments characterized by high resistivity values (> 1,300 Ωm). There are several isolated areas of lower resistivity values (< 20 Ωm) identified as shallow landslide blocks in the profile from 0 to the 32nd m.

The ERT C-C' profile of an alluvial fan (Fig. 5b) revealed that the accumulation had embedded into the floodplain deposits. In comparison with other visible forms, this area is represented by relatively low resistivity values (ranging from 200 to 300 Ωm). A visible layer of higher resistivity values (> 400 Ωm), which can be interpreted as sediments of the floodplain, was identified in the fundament of the alluvial fan. A layer of lower resistivity values (< 200 Ωm) in a depth of ca. 4 m is represented by bedrock built of thin-bedded flysch.

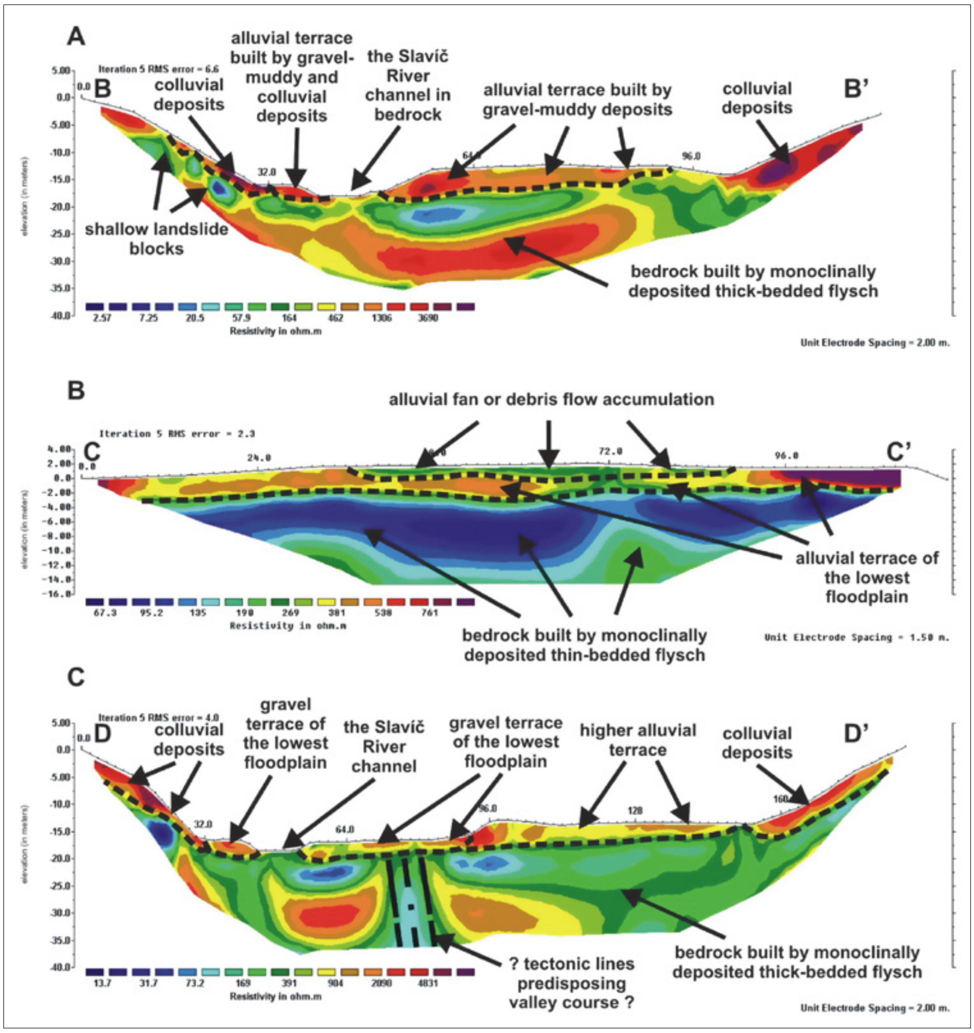

Fig. 5: ERT profile across: A – valley in the upper part of the basin (the profile is identified as B-B' in Fig. 2), B – alluvial fan or debris flow accumulation (the profile is identified as C-C' in Fig. 2), C – valley in the middle part of the basin (the profile is identified as D-D' in Fig. 2)

The ERT D-D' profile (Fig. 5c) across the valley in the central part of the basin showed relatively higher resistivity values (> 800 Ωm) within the floodplain sediment deposits (profile stationing 32–46 m and 54–150 m). The central and bottom parts of the profile are represented by resistivity areas ranging from 30 to 400 Ωm and from 400 to 2,000 Ωm, which can be caused by a sub-horizontally bedded clay stone formation underlain by a sandstone formation. A layer of colluvial sediments (resistivity values > 2,000 Ωm) is visible in the area of adjacent slopes. A structure of vertical character occurring in the central part of the profile was identified as a tectonic line predisposing the valley course (resistivity values < 80 Ωm).

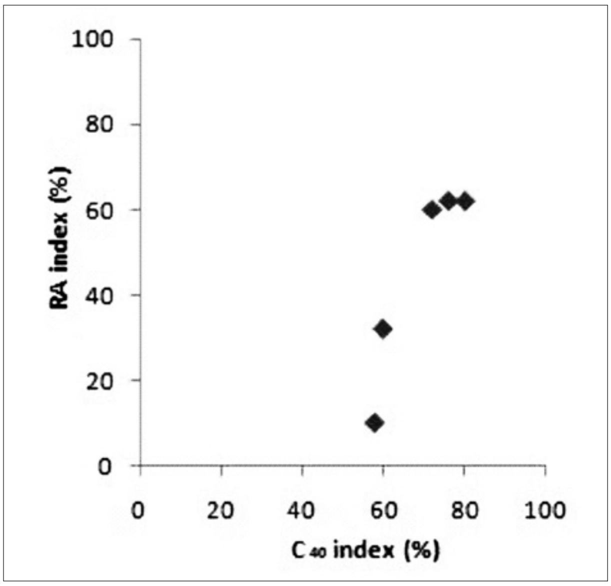

Fig. 6: Relation between RA and C_{40} indices

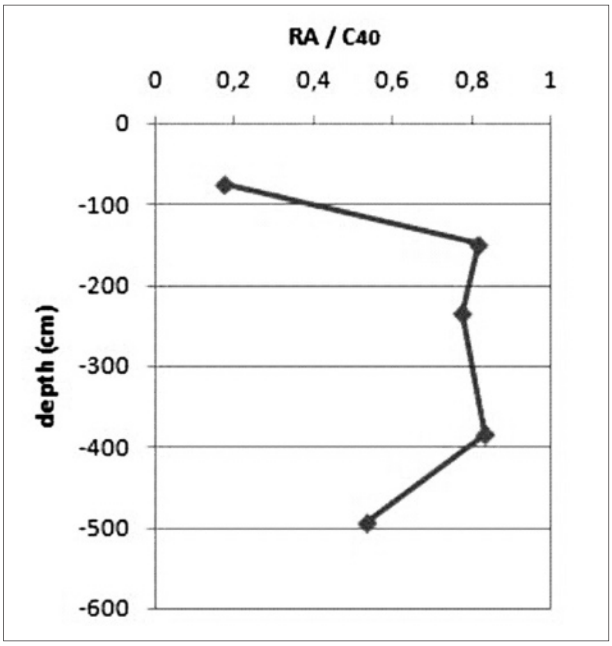

Fig. 7: Development of the RA / C_{40} index with the increasing depth

Properties of the valley fill deposits of one of the river terraces are expressed in the RA and C_{40} indices. The RA index values vary from 10–62%, which points to relatively small roundness linked with colluvial accumulation zone of the basin. The C_{40} index ranges from 58–80%. The relation of particle roundness (transport distance) and particle shape is expressed by the RA / C_{40} index (Fig. 7). The relation of the RA and C_{40} indices is shown in Fig. 6. Values of this index reveal no variable tendency with the increasing depth (Fig. 6). However, some exceptions were found, e.g. at depths of 0.75 m and 4.95 m where higher roundness was identified.

Mean direction of deposited sediments in the Slavíč River basin is highly variable. Mean resultant direction in the position of 0.3 m > x > 1.3 m is between 100–280° with a 95% confidence interval of ± 90° (Fig. 8). According to Pettijohn et al. (1973), such a direction is interpreted as bimodal.

The layer series in the position of 4.7 m > x > 5.4 m has a similar character. Mean resultant direction varies from 129–309° with a confidence interval of ± 90°. This direction is described as polymodal according to Pettijohn et al. (1973).

The upper layer in the position of 0.0 m > x > 0.3 m is built by the loamy-sandy horizon of sporadically organic material, forest litter and heavy root system. Based on these factors, the horizon can be classified as belonging to modal cambic fluvisols according to Němeček et al. (2001).

The layer in the position of 0.3 m > x > 1.3 m (Fig. 8) contains a high volume of matrix of dark brown colour. The particles are small to middle-sized. The layer, which belongs to the Gh lithofacies (according to Miall, 2006), revealed a heavy root system. The RA index (10%) points to a higher content of round particles as compared with other layer series. As for roundness, most represented are the classes of sub-rounded particles (46%) and sub-angular particles (32%). The C_{40} index is 58%.

The layer in the position of 3.2 m > x > 4.7 m (Fig. 8) contains a minimal volume of matrix, which has ochre-brown colour. The size of particles varies from small to middle-sized gravel. This layer series belongs to the Gp lithofacies (after Miall, 2006). The RA index (62%) shows a significantly smaller content of round particles in comparison with the layer series at a depth from 0.3 m to 1.3 m. As for roundness, the most represented classes are those of angular particles (48%) and sub-angular particles (26%). The C_{40} index value is 76%.

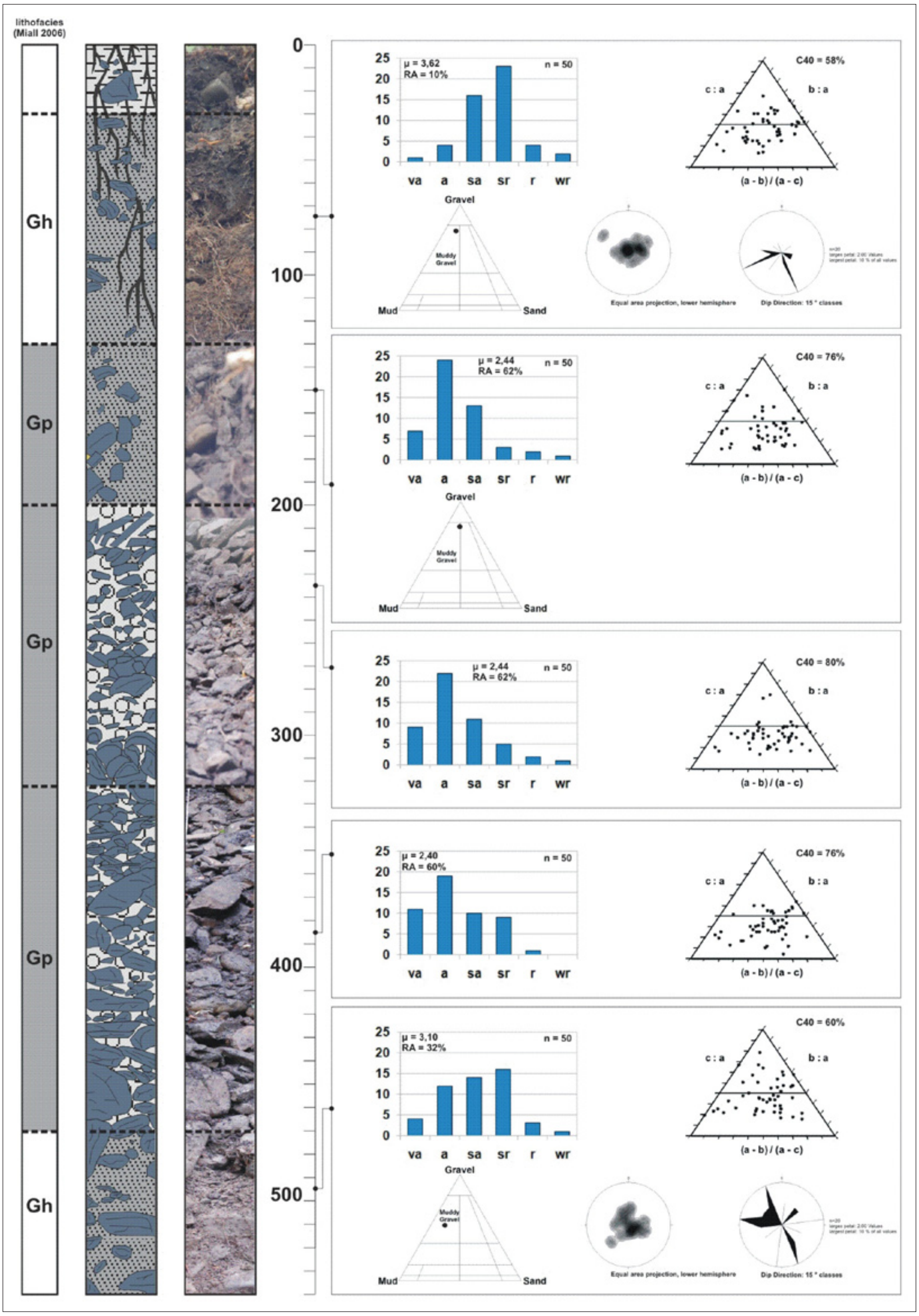

Fig. 8: Lithofacies (according to Miall, 2006) in the studied outcrop, graphical indication of the RA and C_{40} indices and fabric analysis of particles and grain-size analysis

Particles of the layer in the position of 2.0 m > x > 3.2 m (Fig. 8) vary from small to middle-sized. The sporadic occurrence of matrix in spaces between the gravel particles is of clayey character and bright grey colour. At a depth of 2.1 m > x > 2.4 m there is a layer of sub-horizontally deposited angular middle-sized gravel particles. This layer series belongs to the Gp lithofacies. The RA index (62%) shows a smaller volume of round particles. As for roundness, the most represented classes are those of angular clasts (44%) and very angular clasts (22%). The C_{40} index value is 80%.

The layer in the position of 3.2 m > x > 4.7 m (Fig. 8) contains from small to bigger particles; however, small to middle-sized particles prevail. Matrix is absent. These layer series belongs to the Gp lithofacies. The

Land use classiffy	Year 1836		Year 2006	
	area (km^2)	area (%)	area (km^2)	area (%)
Forest	11.064	63.59	15.978	91.74
Arable land	0.790	4.54	–	–
Permanent crops	0.020	0.11	0.019	0.11
Grass land	5.507	31.65	1.284	7.37
Built-up area	0.016	0.09	0.040	0.23
Other land	0.002	0.01	–	–
Water	–	–	0.095	0.55

Tab. 1: Space distribution and calculated volumes of leading accumulation forms in the Slavíč River basin (Škarpich et al., 2010)

RA index (60%) points to a relatively small content of round particles in comparison with the layer series at a depth from 1.3 m to 3.2 m. Most represented are the classes of angular clasts (38%) and very angular clasts (22%). The C_{40} index value is 72%.

The lowermost layer in the position of 4.7 m > x > 5.4 m (Fig. 8) is highly specific for its wet and considerably plastic matrix of grey-brown colour. Compared with other layer series, this layer, which belongs to the Gh lithofacies, contains matrix at a large volume. The RA index value (62%) points to the very round particles, which is also in contrast to others layer series. Most represented are the classes of sub-rounded clasts (32%) and sub-angular clasts (28%). The size of gravel particles varies from small to big. The layer has a visible character of gleyzation caused by flood discharges that reach the base of the terrace outcrop. The C_{40} index value is 60%.

5. Discussion and conclusion

Leading accumulation forms in the Slavíč River basin comprise an alluvial fan, debris flow accumulations, floodplain and river terraces (Škarpich et al., 2010). Spatial patterns and calculated volumes are presented in Tab. 1 and Fig. 3 (see cover p. 2). Thickness of the floodplain was identified to be ca. 2–3 m and thickness of river terraces ca. 5–7 m (Fig. 4 and Fig. 5c).

In comparison with the other parts of the Morávka River basin (Škarpich et al., 2010), the measurement of the Slavíč River basin valley-fill deposits shows a higher sediment thickness. The questions related to the inner structure and genetic type of higher situated all terrace deposits could not be solved using the electrical resistivity tomography. This problem was solved by means of a test pit. A studied outcrop brought facts about smaller polygenesis of the valley fill. Sediments analyzed from the given outcrop were interpreted as deposits of a braided river pattern with a high supply of gravels and cobbles. This assumption is confirmed by the interaction between the RA and C_{40} indices (Fig. 6), as compared with Šilhán and Pánek (2007) and grain size distribution. Relatively high thickness and poor alternation of the layer series of various geneses indicate low dynamics of the development of accumulations in the area. The valley fill is predominantly built of gravel with some matrix content in some layer series. The layer series of Gh lithofacies have higher

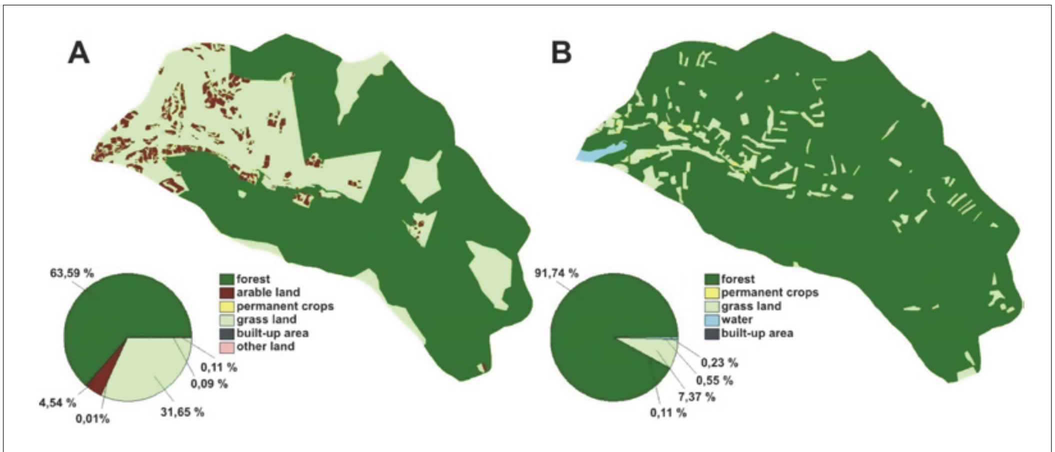

Fig. 9: Land use in the Slavíč River basin in: A – year 1836, B – year 2006 (Source: Voznicová, 2008)

roundness values. These can be interpreted as secondly accumulated sediments scoured from alluvial fans (compare with Šilhán, Pánek, 2007). This assumption is supported by the higher contents of the fine-grained material. The layer series of Gp lithofacies have lower values of the RA index. It may indicate shorter distance and transport time. The absence of the fine material points to the river pattern with a high rate of bed-load transport. The interpretation of the shape index (C_{40}) is disputable. A significant role in the final shape of particles is played by the geological setting of the basin. It is represented by a flysch nappe structure in which sandstone layers rhythmically alternate with fine clay stone layers. With regard to the rapid weathering of clay stones and the typically tabular decomposition of sandstones, the evaluation of C_{40} index is inaccurate.

Due to the lack of suitable material, it is impossible to obtain a relevant absolute time of landform genesis. General problem is the absence of organic material and the chaotic deposition. Based on the up to-date research published by Menčík et al. (1983) and Menčík, Tyráček (1985), we can interpret the remnants of river terraces as products of deposition originating from the last glacial stage (Vistulian). This can be confirmed by the absence of the fine fraction in accumulations with the dominant gravel content. In the floodplain area about 300 meters upward from the mouth to the Morávka water reservoir we can observe channel anabranches. This anabranching could be a reaction to higher sediment supply due to intensive deforestation (Fig. 9) of the Moravskoslezské Beskydy Mts. in the period of the Walachian colonization or it is erosion of the originally thick accumulation now preserved as river terrace.

Fluvial geomorphological mapping shows that alluvial fans or debris flow accumulations lie on the floodplain (Fig. 3 – see cover p. 2). The origin of these forms has been specified by Šilhán (2010a). In his opinion, the processes of sediment supply have structural control. The main source areas are situated in tectonic zones and lithological boundaries of rock formations. In respect of relative position, it is possible to presume that the accumulations are of the postglacial age (Holocene). These presumptions are supported by the ERT profile (Fig. 5a) which runs through an alluvial fan in the lower part of the basin. The ERT profile shows that the accumulation penetrates the floodplain deposits, which can be caused either by pressure during material intrusion or by deposition around the fan after accumulation. Based on ERT visualization, we incline to the first presumption.

The valley fill in the upper part of the basin is of polygenetic character represented by accumulations of fluvial deposits, debris flows and proluvial deposits. The thickness of the valley-fill deposits in the upper part of the Slavíč River basin was specified at ca. 3–5 m (Fig. 5b).

Although the presently occurring processes in the basin are not as intensive as in the past, they have an important influence on the channel, gully network development and, in some cases, landslide activity (Rybář et al., 2008) in contact with the channel (e.g. Fig. 5a). They have been affected by afforestation (Fig. 9) since the end of the 19th century. Significant impact on present sediment deposition has also the Morávka water reservoir whose construction changed the level of erosion base and induced accelerated backward accumulation (sensu Holbrook, 2006). At the mouth of the reservoir, a delta formation is observed along with the anabranching channel pattern (Fig. 10 – see cover p. 2). Upper parts of the basin are affected by intensive deep erosion due to anthropogenic pressure. The information on the present gully erosion processes has been brought by Šilhán (2010a, b), especially with respect to the latest debris flow activity and proluvial deposition.

Acknowledgements

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SPATIAL DIFFERENTIATION OF SELECTED PROCESSES CONNECTED TO THE SECOND DEMOGRAPHIC TRANSITION IN POST-SOCIALISTIC CITIES (THE EXAMPLES OF BRNO AND OSTRAVA, CZECH REPUBLIC)

Tomáš KREJČÍ, Stanislav MARTINÁT, Petr KLUSÁČEK

Abstract:

The paper deals with the issue of population and its spatial changes in two second-order cities in the Czech Republic (Brno and Ostrava) after 1989 when the post-socialist period in Central Europe began. We analysed two different hierarchic levels of the urban space: city districts and basic settlement units (within inner cities). Research on evidence for the second demographic transition was carried out. Most attention is paid to the analyses of three selected processes: population increase/decrease, population ageing and household structure changes.

Shrnutí

Prostorová diferenciace vybraných procesů druhého demografického přechodu v postsocialistických městech (na příkladu Brna a Ostravy v České republice)

Příspěvek se zabývá problematikou populačních prostorových změny na území dvou velkých měst druhého řádu České republiky (Brna a Ostravy) v období po roce 1989, kdy byla v rámci celé střední Evropy zahájena nová postsocialistická epocha. Z prostorového hlediska je pozornost zaměřena na dvě hierarchické úrovně urbánního prostoru – úroveň městských částí a úroveň urbanistických obvodů v rámci vnitřních měst. Výzkum se věnuje zejména otázkám spojeným s druhým demografickým přechodem a je primárně založen zejména na časových a prostorových analýzách vývoje počtu obyvatelstva, stárnutí populace a změn ve struktuře domácností.

Key words: *Second demographic transition, depopulation, population ageing, household structure, post-socialist city*

1. Introduction, objectives and methods

Population in the largest cities of the Czech Republic was increasing almost continually during the 19th and 20th centuries. At the end of the 20th century (approximately since the 1990s) the situation changed when after the decades of urbanisation dominance rather substantial depopulation was recorded. On the one hand, the depopulation of large cities was influenced by intensifying residential suburbanisation (construction of family houses and flats beyond the administrative limits of the studied cities) and general changes of urban spatial structure (case of the Czech Republic – e.g. Sýkora, Kamenický, Hauptmann, 2000; Steinführer, 2006, cases of other post-socialistic countries – e.g. Węclawowicz, 1997; Gentile, 2003).

On the other hand, a fundamental turn in the reproductive behaviour appeared (fertility falling below replacement level in particular), which can be seen as an evidence of the second demographic transition (van de Kaa, 1987, 1994, 1997; Srb, 1991). The second demographic transition (SDT) is a theoretical concept created in the mid 1980s by Lesthaeghe and van de Kaa (1986). In their opinion, the SDT marked a significant change in the demographic behaviour of people, which first began during the 1960s. Great and significant changes in people's behaviour were first observed in northern Europe (see Cliquet, 1991), from where they spread to western European countries (Belgium, France etc.). Later, the SDT expanded to central and eastern Europe as well as outside of Europe. We can follow the continuing process of the SDT including some new features e.g. from Finland (Valkonen et al., 2008 or Marteleto (2010).

There have been various interpretations of the SDT. For example, Cliquet (1991) argues that the SDT is only a continuation of the first demographic transition (FDT). In this respect, it is interesting that Lesthaeghe and van de Kaa (1986) titled their first contribution with a question mark (Two demographic transitions?). Another ambiguity refers to the starting point of the SDT process. It is assumed that the first features (discussed below) were seen during the sixties, but Lesthaeghe and Surkyn (2004) point out the high rate of divorce in the US and Scandinavian countries from the mid 1950s. We can say that the SDT process started after 1990 and is still continuing in the Czech Republic, and we are also able to recognise two different opinions. Hamplová et al. (2003), emphasize that the demographic situation in the Czech Republic is similar to the "classic" (west European) SDT where demographic changes were caused by changes of behaviour and value orientation. A second point of view says that changes in fertility and nuptiality are negative effects of economic transition and are inspired by rational choice, for example, in the labour market (in the same book, Rychtaříková compares this type with the crisis in the 1930s).

It is generally accepted nowadays that main reasons for the SDT were variations in value orientation and resultant changes in the behaviour of inhabitants who placed greater emphasis on their individuality and self-fulfilment – in this context, Lesthaeghe (1995) refers to Maslow´s hierarchy of need where more wealth means that the higher needs of a human being can be satisfied. The most important features of the second demographic transition can be seen in total fertility decline, increasing divorce rate, increasing cohabitation and increasing use of effective contraception. Van de Kaa (1987) emphasizes that cohabitation became a substitute for marriages, the central point of interest having become the self instead of children, and at the same time, there were increasing variation in the forms of households. According to Lesthaeghe (1995) because of the variety of factors and features of the SDT, there have been triple revolutions in western countries: sexual, contraceptive and political.

In this article the selected measurable characteristics, which are – in our opinion – the most significant for big Czech cities are discussed. These indicators are connected especially with three very important demographic processes:

- population increase and decrease,
- population ageing,
- change in the household structure.

The issue of the second demographic transition has been widely debated not only among experts from various scientific disciplines (such as demography, geography, sociology and economics). It has also become an item of interest for a number of politicians both in the European Union and in the Czech Republic. The processes connected with the second demographic transition have important impacts on the socio-spatial structures of urban space. Depopulation can influence in some cases the shrinkage of cities and the issue of shrinking cities has been discussed for example in connection with East Germany where the "natural trends" to depopulation were supported by massive emigration after reunification of the country and where local political representatives had to find a solution for many cases of abandoned housing (Kabisch, 2007).

Furthermore, the decreasing average size of households may result in growing special demands for housing and new public housing policies (Balchin, 1996). Unfavourable population development (particularly depopulation and population ageing) calls for fundamental changes and political reforms and decisions, for instance in the field of retirement systems (e.g. Burcin, Kučera, 2002), senior citizens care or in the health service (Fiala, Langhamrová, 2007). Demographic changes thus have a great impact on the economy (e.g. Koschin, 2005). The above-mentioned demographic changes certainly do not affect the whole of the Czech Republic with the same intensity, but result in rather significant territorial inequalities. The article is focused on examining the spatial impact of the selected socio-demographic processes relating to the second demographic revolution in two major cities in the Czech Republic (Brno and Ostrava) in the period after 1989. Attention is paid to Brno and Ostrava not only because these two cities are approximately comparable in terms of population size (we selected the second and the third largest city in the Czech Republic) but also we believe that this socio-demographic analysis can bring new information because it is comparing two cities with different models of development. On one side of the comparison is Brno, which was already an important administrative centre in the medieval period and later developed due to textile and engineering industries. By contrast, Ostrava became an important city due to coal-mining and metallurgical plants in the 19th century. It could be assumed that the different forms of development in the socialist era 1948–1989 (for example, the enormous support given to development in Ostrava in contrast to relatively little investment in Brno) influenced the processes of the second demographic transition.

The issue of urban space can be approached from various perspectives and highly distinct methodological procedures can be applied to research the issue. From the territorial point of view, large city research can be implemented either within the current administrative city limits, or it can be enlarged to the whole functional city region (Ouředníček, 2006). In the case of the second eventuality, chosen municipalities in the researched city hinterland that are strongly linked with the given urban space are examined in detail. The level of the relationship between the urban core and the surrounding hinterland is often determined by the intensity of daily commuting to work or services (e.g. Boudreau et al., 2007; Greene, 2008). To assess spatial variations of the examined characteristics on an actual administrative area of big cities within the Czech Republic, current administrative-statistical units (city districts; basic settlement units) or possibly one's own territorial morphogenetic units defined on the basis of specific criteria can be applied. For example, Mulíček (2004) divided the city of Brno into the following six morphogenetic zones: historical core, inner city I, inner city II, villa districts, housing estates and suburban zone on the basis of the different character of housing development, as a consequence of historical development and integration of formerly suburban municipalities into the city organism.

The application of the above-mentioned approaches brings not only advantages but also certain disadvantages. For instance, the assessment based on morphogenetic zones takes into account the true character of the urban environment and thus it could be supposed that qualitatively parallel territorial units will also have a similar occurrence of specific phenomena; certain disadvantage may be that data aggregation from statistical units into morphogenetic zones depends to a certain extent on the subjective decisions of the researcher. On the other hand, other phenomena can be significantly influenced by decisions made by political representatives. It is also necessary to take into consideration the official territorial administration (for example the level of municipalities or city districts), under which the performance of self-government or delegated state administration is executed.

The decision whether to apply the administrative statistical units or the morphogenetic zones thus depends on various factors (for example the type of issue that is being examined, for what purposes and for who it is produced, etc.) The question of data accessibility must also be considered since a great amount of official statistical data relating to demographical changes is available only at the level of municipalities; detailed data at a sub-municipal hierarchical level is only available from censuses. Here it is necessary to note that data from the Czech Statistical Office concerning the population number is available annually only at a level of the municipality and with the exception of Prague, the official statistics unfortunately do not provide parallel data for city districts of other big cities in the Czech Republic. The most up-to-date data for all lower-level administrative statistical territorial units in Brno and Ostrava (both city districts and basic settlement units) is not available at present. So far, it refers to the situation in March 2001 when the last census took place in the Czech Republic.

In the presented contribution, the attention was focused on two different hierarchical levels. The first one is the level of city districts, the basic level of local government, which significantly influences the implementation of a range of environment parameters (for example new housing stock development, flat policy concerning municipal ownership of flats, level of rentals, privatization etc.). The second level is that of the inner city in Brno and Ostrava – here the analysis is carried out up to the level of basic settlement units that represent the most detailed territorial statistical units available. The area of the inner city in both cities was not defined using entirely identical methods because whereas Brno is a typical monocentric city, Ostrava is distinctive for its polycentric character. The inner city in the case of Brno was defined on the basis of two selected morphogenetic characteristics – the age of the housing stock and the type of housing development. Thus, basic settlement units with a prevalence of houses built before 1945 were integrated into the area of the inner city of Brno, and at the same time, one more condition had to be fulfilled with these basic settlement units – that at the time of census in 2001, flats in apartment houses outnumbered those in family houses. The definition of the inner city in this way tried to exclude basic statistical units with a prevalence of relatively new post-war housing development (for example housing estates) and further to exclude basic statistical units with older villas (luxury pre-war villa quarters). In the case of Ostrava, the inner city was defined predominantly on the basis of its geographical position (only the oldest of all three centres of this polycentric city was chosen) and some selected characteristics relating to housing stock age and housing development type were taken into account here as well. The inner city of Brno consists of 33 basic settlement units while the inner city of Ostrava consists of 21 basic settlement units.

2. Development of the population after 1989

The population development in the two cities between 1991 and 2007 is shown in Tab. 1. Not only several similar trends were observed but also some differences were found. While in Brno, the population was increasing in the early 1990s (until the end of 1993), in Ostrava, a population decrease had already started which was partly caused by the negative migration balance in that period (Fig. 1), while the migration balance was still positive in Brno (Fig. 2). It is interesting that the natural population increase between 1991 and 1993 in Ostrava was positive and in Brno, it was negative, which may have been influenced by the different qualitative structure of the Ostrava's population (relatively young population and major share of population with lower level of education compared with that of Brno). Since 1994, the total population of Brno has been decreasing – firstly as a result of the negative population increase (natality decrease) and since 1996 because of the negative migration balance (more immigrants than emigrants). The unfavourable population trends started to change in 2006, when natural increase started to show positive values and out-migration was considerably reduced in comparison with previous years. Also in 2007, the population in Brno increased thanks to a positive migration balance. Certain changes took place in Ostrava at this time as well (positive natural growth in 2006 and 2007) although the total population was still decreasing as a result of a relatively high negative value of migration balance in 2007, although at a lower rate than in the previous period. The economic success of Brno (and slump of Ostrava) in the 1990s and a change of the population behaviour as compared with the previous period evidently caused the trends outlined above. However, with the more dynamic economic growth and the recent inflow of foreigners in Ostrava, the demographic trends are now more positive.

As mentioned above, data concerning each city districts and inner cities is only available for the 1991 and 2001 censuses. Population decrease between 1991 and 2001 was higher in the inner cities compared to other parts of the cities (Tab. 2), which was above all linked to the commercialization of city centres (using flats as commercial spaces – stores, offices etc.).

City	1991	1992	1993	1994	1995	1996	1997	1998	1999
Brno	388,454	389,999	390,112	389,965	388,899	387,570	385,866	384,727	383,569
Ostrava	327,413	327,055	326,242	325,670	324,813	323,870	323,177	322,111	321,263
City	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	
Brno	381,862	373,272	370,505	369,559	367,729	366,757	366,680	368,533	
Ostrava	320,041	315,442	314,102	313,088	311,402	310,078	309,098	308,374	

Tab. 1: Population development in Brno and Ostrava between 1991–2007
Source: Czech Statistical Office (www.czso.cz)

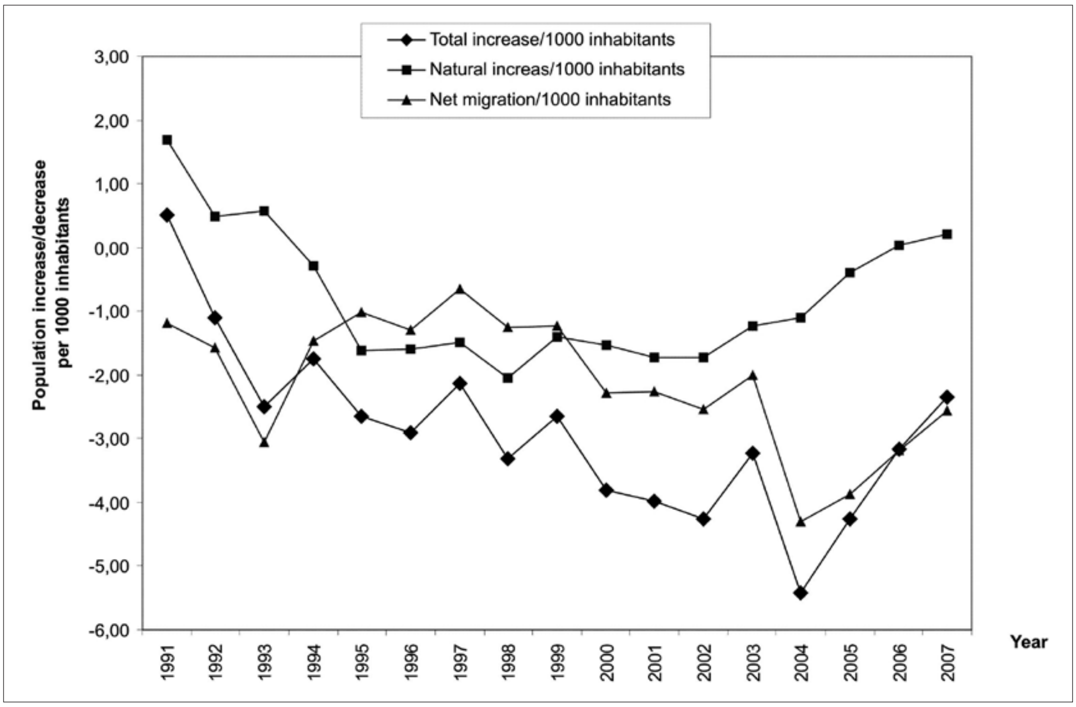

Fig. 1: Population increase/decrease per 1.000 inhabitants in Ostrava (1991–2007)
Source: Czech Statistical Office (www.czso.cz)

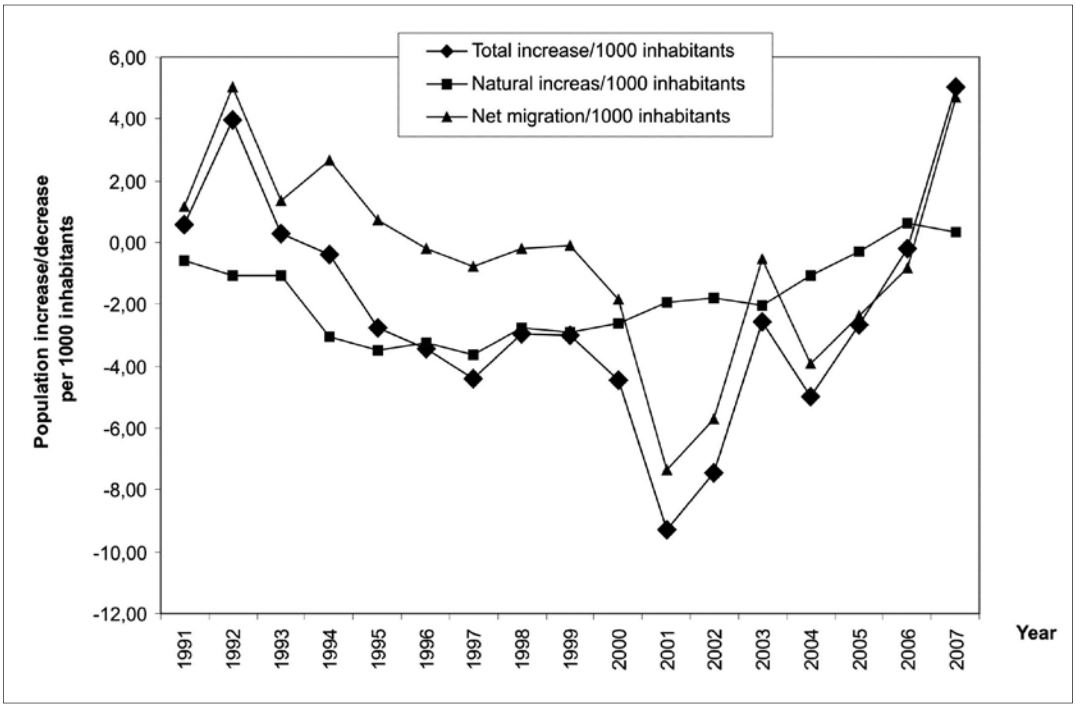

Fig. 2: Population increase/decrease per 1,000 inhabitants in Brno (1991–2007)
Source: Czech Statistical Office (www.czso.cz)

Area	Population (census 1991)	Population (census 2001)	Population change 2001/1991 (%)
Brno	388,296	376,004	– 3.2
Brno Inner city	66,813	60,849	– 8.9
Ostrava	327,371	316,698	– 3.3
Ostrava Inner city	26,263	23,629	– 10.0

Tab. 2: Population change between census years 1991 and 2001 in Brno and Ostrava
Source: Censuses 1991, 2001 (Czech Statistical Office, www.czso.cz)

From the spatial point of view it is obvious (Fig. 3) that depopulation trends in the period 1991–2001 occurred in relatively older residential built-up areas where major parts of both inner cities are located (for example city districts Brno-Centre and Žabovřesky in Brno, Moravská Ostrava, Přívoz and Poruba in Ostrava), while the population increase was observed in areas with new suburban developments of family houses (for example city districts Ivanovice and Útěchov in Brno or Krásné Pole and Svinov in Ostrava) and housing estates (e.g. Nový Lískovec in Brno). Within the areas of inner cities, different tendencies can be detected in each of the basic settlement units. In the case of Brno, the inner city can be divided into two parts – a traditional residential area located in the north-western part of the inner city, where we can record depopulation, and expanding areas in the south-eastern and eastern parts of the inner city (formerly of industrial character), where the population is mostly formed by Roma people. In the case of Ostrava, the inner city population decline is spatially extensive. As it is in Brno, the population increase occurs in areas inhabited mainly by Roma people.

In spite of the fact that the total population in Brno and Ostrava was mostly decreasing in the period after 1989, the number of foreigners significantly increased in the period 1996–2006 (see Tab. 3). These increasing numbers of foreigners can also significantly influence the future processes of the second demographic transition not only in Brno and Ostrava, but also in all the Czech Republic, because foreigners bring with themselves – together with their customs and usages – also the specific demographic behaviour that can modify demographic characteristics of the majority population. This trend brings not only many indisputable positive benefits, but also many new problems, which arise above all within the context of the integration of newcomers to the majority society. In this context, it has to be pointed out that immigrants have often originated from different socio-cultural environments, which complicates their successful adaptation to local conditions.

3. Population ageing

Population ageing in both cities can be demonstrated by the age index that indicates the share of population

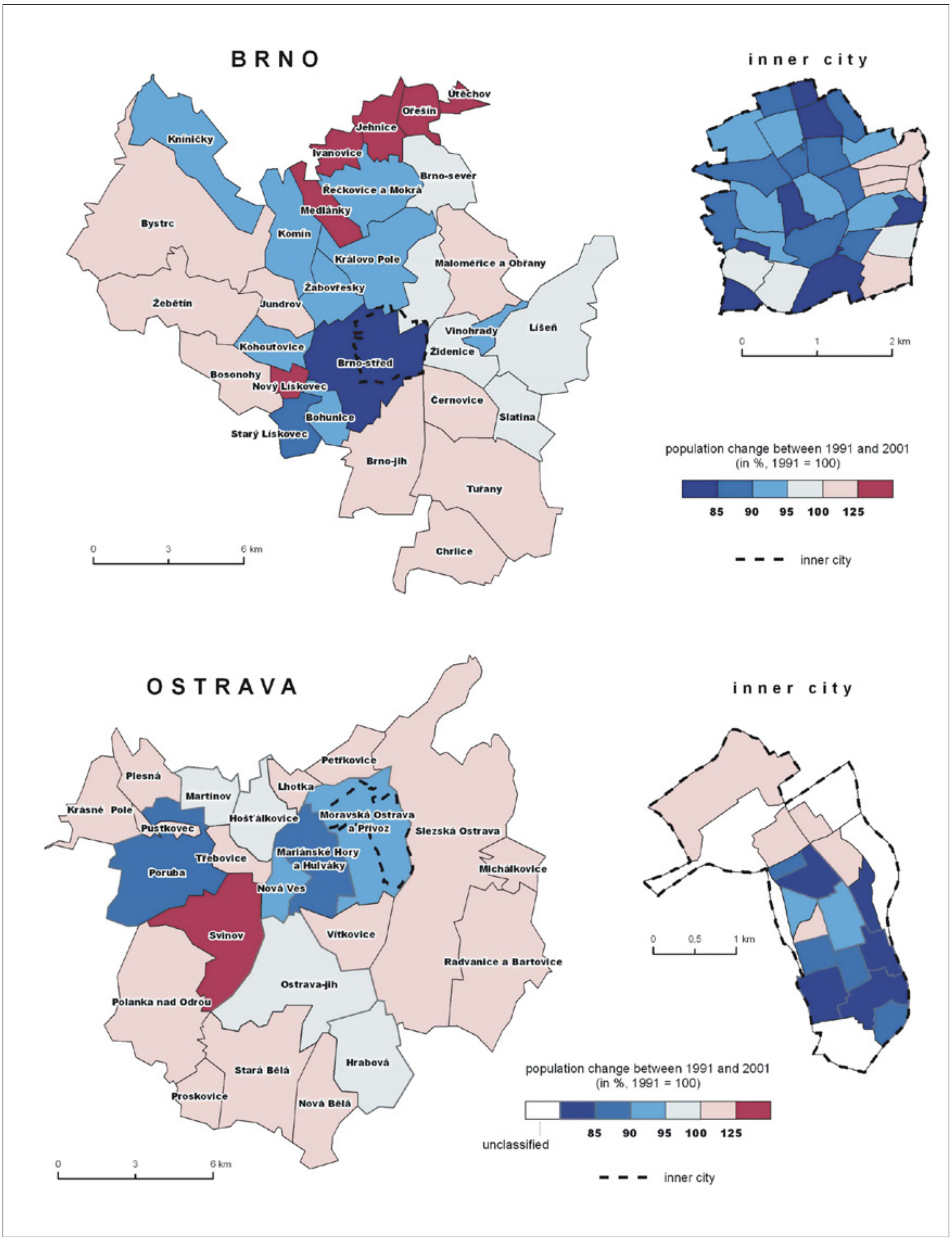

Fig. 3: Development of population in Brno and Ostrava in the period 1991–2001
Source: Censuses 1991, 2001 (Czech Statistical Office, www.czso.cz)

	1996	2001	2002	2003	2004	2005	2006	2007
Foreigners in Brno (abs.)	6,967	9,127	10,673	11,773	12,284	12,365	14,730	16,447
Foreigners in Brno (%)	1.80	2.40	2.90	3.20	3.30	3.40	4.00	4.50
Foreigners in Ostrava (abs.)	8,163	6,575	6,894	7,399	7,084	7,339	7,912	9,210
Foreigners in Ostrava (%)	2.50	2.10	2.20	2.40	2.30	2.40	2.60	3.00

Tab. 3: Foreigners in Brno and Ostrava (1996–2007)
Source:Czech Statistical Office (www.czso.cz)

in the age category over 65 relative to the population in the age category 0–14. The age index value significantly increased both in Brno and in Ostrava during 1991–2007 (see Tab. 4) which was connected with total population ageing in the Czech Republic. It is very interesting that the age index value in Brno was noticeably higher than the one in Ostrava. The relatively younger population in Ostrava compared to Brno was partly a result of the important immigration flows during socialism, when not only the city of Ostrava, but the entire Ostrava industrial agglomeration belonged to those areas with huge state support for immigration (increased demand for labour in heavy industry). This state policy (accompanied by the provision of cheap housing) resulted in the immigration of younger people with lower qualification and resulted in a more difficult transition process during the 1990s, which is another specific feature of the Ostrava's population.

The population ageing continued in the city districts of Brno and Ostrava at different levels of intensity (Figs 4 and 5 – see cover p. 3 and 4, Tab. 5). In the inter-censual period of 1991–2001, Brno experienced an increase of the age index in city districts of old traditional residential character (for example Královo Pole, Žabovřesky, Brno-Centre). In 2001, a larger proportion of younger people remained in newer housing estates (Vinohrady, Nový Lískovec) and in areas of family houses in the northern outskirts of Brno (Útěchov, Ořešín). On the other hand, the population ageing in 1991 in Ostrava was found only in some of older housing estates built in the 1950s and early 1960s (predominantly Poruba). The oldest population can thus be found in the old miner's municipalities (now city districts of Ostrava) located near the eastern city limits (Radvanice and Bartovice) from where young families had gradually moved away because of the neighbouring ironworks and polluted environment. The most populous Ostrava-City district, Ostrava-South, was at the beginning of the 1990s a very young area as result of huge immigration. Ten years later (2001), the Ostrava-South kept its position as the youngest city district in Ostrava even though it was getting relatively older as well. In 2001, the city district of Vítkovice was also a very young area with

City	1991	1992	1993	1994	1995	1996	1997	1998	1999
Brno	73.9	77.2	80.4	84.3	88.2	92.3	96.4	100.2	103.8
Ostrava	55.5	57.4	59.7	62.6	65.1	67.5	70.1	72.2	74.6
City	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	
Brno	107.2	111.6	114.1	117.3	120.2	123.5	127.8	131.0	
Ostrava	77.0	79.4	82.0	85.2	88.5	93.6	98.8	102.4	

Tab. 4: Age index (65+ / 0–14 in %) of Brno and Ostrava population in period 1991–2007
Source: Czech Statistical Office (www.czso.cz)

Census 1991										
Area	Population total	Main age groups								Index of ageing (%)
		0–14		15–64		65+		undefined		
		total	%	Total	%	total	%	total	%	
Brno	388,296	76,411	19.7	256,664	66.1	55,221	14.2	0	0.0	72.3
Brno Inner city	66,813	12,077	18.1	41,762	62.5	12,974	19.4	0	0.0	107.4
Ostrava	327,371	68,234	20.8	222,038	67.8	37,099	11.3	0	0.0	54.4
Ostrava Inner city	26,263	5,488	20.9	17,022	64.8	3,753	14.3	0	0.0	68.4
Census 2001										
Area	Population total	Main age groups								Index of ageing (%)
		0–14		15–64		65+		undefined		
		total	%	Total	%	total	%	total	%	
Brno	376,004	54,008	14.4	263,289	70.0	58,707	15.6	168	0.0	108.7
Brno Inner city	60,849	9,304	15.3	40,894	67.2	10,651	17.5	24	0.0	114.5
Ostrava	316,698	51,843	16.4	224,753	71.0	40,102	12.7	46	0.0	77.4
Ostrava Inner city	23,629	3,755	15.9	16,687	70.6	3,187	13.5	11	0.0	84.9

Tab. 5: Main age groups and age indexes for Brno and Ostrava and their inner cities (1991 and 2001)
Source: Censuses 1991, 2001 (Czech Statistical Office, www.czso.cz)

a significant share of Roma population and with their different patterns of demographic behaviour (above all higher fertility and consequent higher share of age category 0–14). Relatively older populations can be found partly in city districts in the outskirts of Ostrava (Hrabová, Proskovice, Hošťálkovice – which are not so attractive for suburbanization), and partly in the oldest housing estate of Ostrava-Poruba. Areas of both inner cities experienced population development that is in line with general trends, but slightly more intensified. The western belt of housing estates in Ostrava inner city has a relatively younger population; older housing developments are inhabited by older people in both inner cities. Areas populated by Roma people are of great interest. These areas typically have a very young population and are located at what is regarded as "bad addresses" at the peripheries of both inner cities (northern part of the Ostrava inner city, south-eastern part of the Brno inner city). Some of the areas are characteristic by the derelict housing stock.

4. Change of household structure

One of the most useful characteristics when studying the dynamics of the second demographic transition is the share of one-person households (see example of Paris in eighties and nineties by Ogden and Schnoebelen, 2005) which is often higher in inner cities. In the period under examination between 1990 and 2001 the proportion of one person households was increasing very moderately (Tab. 6). It was larger in Brno, which may be connected with the older population of this city. At the beginning of the 1990s one-person households were predominantly made up of older women and it is presumed that their share of one-person households is still rather large even ten years later. A typical figure of the second demographic transition in western cities – one-person households of younger age-groups, – is not still so frequent in the researched cities. The causes are on the one hand the different economic level of the population (income of population) and on the other the deformed housing market in the Czech Republic (state regulations of rentals, expensive market rentals, high price of newly built flats, etc.) In the case of Ostrava, the larger share of one-person households is due to the lower life expectancy of Ostrava men who were working in mines and heavy industries (the figure below).

When analysing the spatial differentiation of one-person households in the city and inner city (Figs 6 and 7), we conclude that Brno is markedly influenced by its monocentric character while Ostrava is not so zonally arranged and features rather a mosaic-like differentiation. The lowest share of one-person households is evident in rural suburban areas in the outskirts of Brno (city districts Bosonohy, Chrlice etc.) and Ostrava (city districts Proskovice and Stará Bělá). In 2001, the moderate increase did not cause any significant spatial changes. One-person households in the inner cities are relatively more concentrated in the eastern part of Brno, while in Ostrava they are located in and close to the historical core.

Census 1991								
Census-households by size	Brno		Brno inner city		Ostrava		Ostrava inner city	
	total	%	total	%	total	%	total	%
Total	165,880	100.0	30,996	100.0	134,149	100.0	11,499	100.0
1-person	51,573	31.1	11,327	36.5	39,852	29.7	4,114	35.8
2-persons	49,020	29.6	9,861	31.8	36,848	27.5	3,092	26.9
3-persons	31,039	18.7	5,070	16.4	25,598	19.1	2,056	17.9
4-persons	28,209	17.0	3,575	11.5	25,873	19.3	1,771	15.4
5 and more-persons	6,039	3.6	1,163	3.8	5,978	4.5	466	4.1
Census 2001								
Census-households by size	Brno		Brno inner city		Ostrava		Ostrava inner city	
	total	%	total	%	total	%	total	%
Total	167,740	100.0	28,994	100.0	140,848	100.0	11,128	100.0
1-person	55,788	33.3	11,226	38.7	47,728	33.9	4,338	39.0
2-persons	52,220	31.1	9,010	31.1	42,509	30.2	3,251	29.2
3-persons	32,032	19.1	4,921	17.0	26,283	18.7	1,921	17.3
4-persons	22,938	13.7	2,899	10.0	20,265	14.4	1,308	11.8
5 and more-persons	4,762	2.8	938	3.2	4,063	2.9	310	2.8

Tab. 6: Households according to size in Brno and Ostrava in 1991 and 2001
Source: Censuses 1991, 2001 (Czech Statistical Office, www.czso.cz)

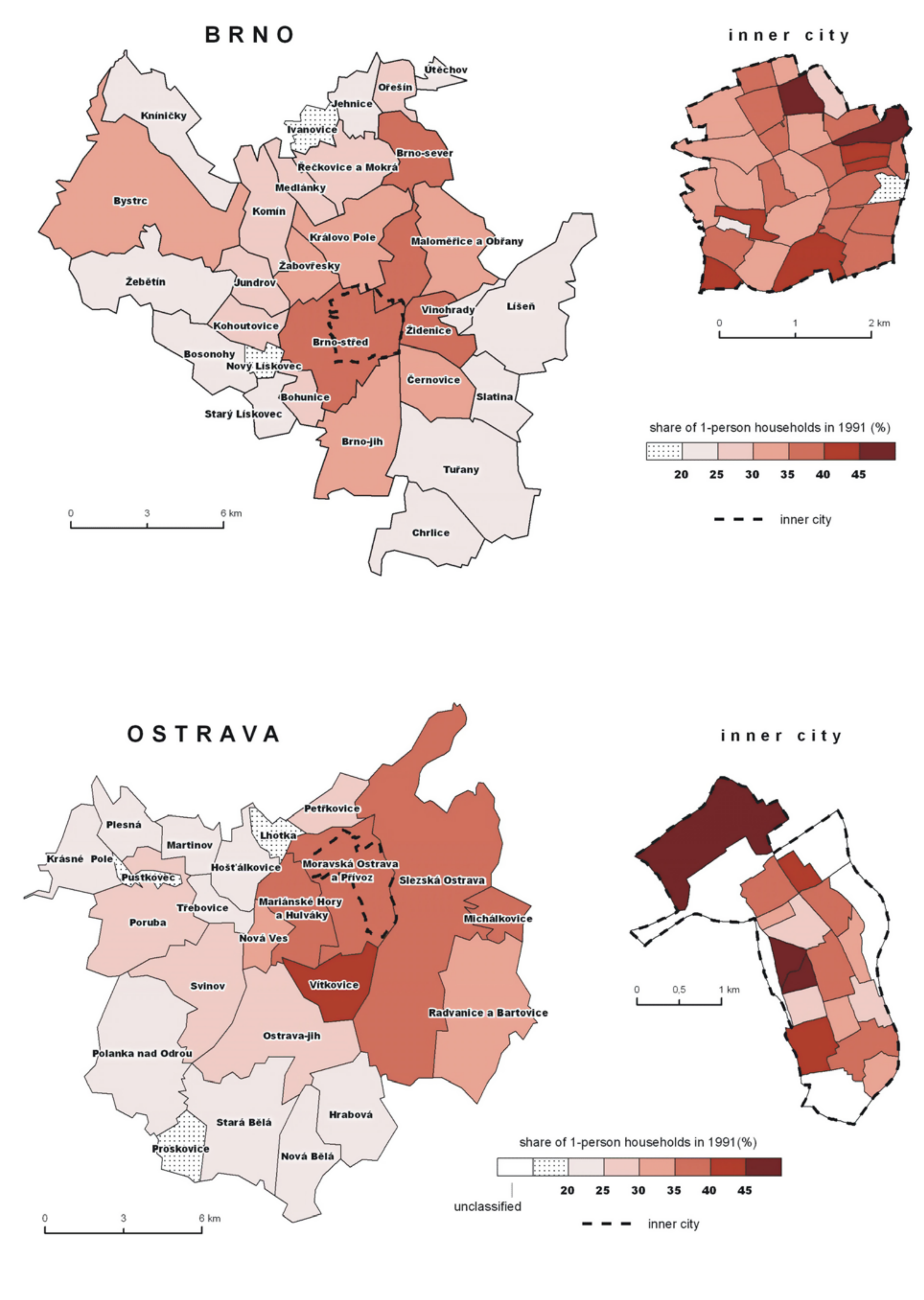

Fig. 6: Share of one-person households in Brno and Ostrava in 1991
Source: Census 1991 (Czech Statistical Office, www.czso.cz)

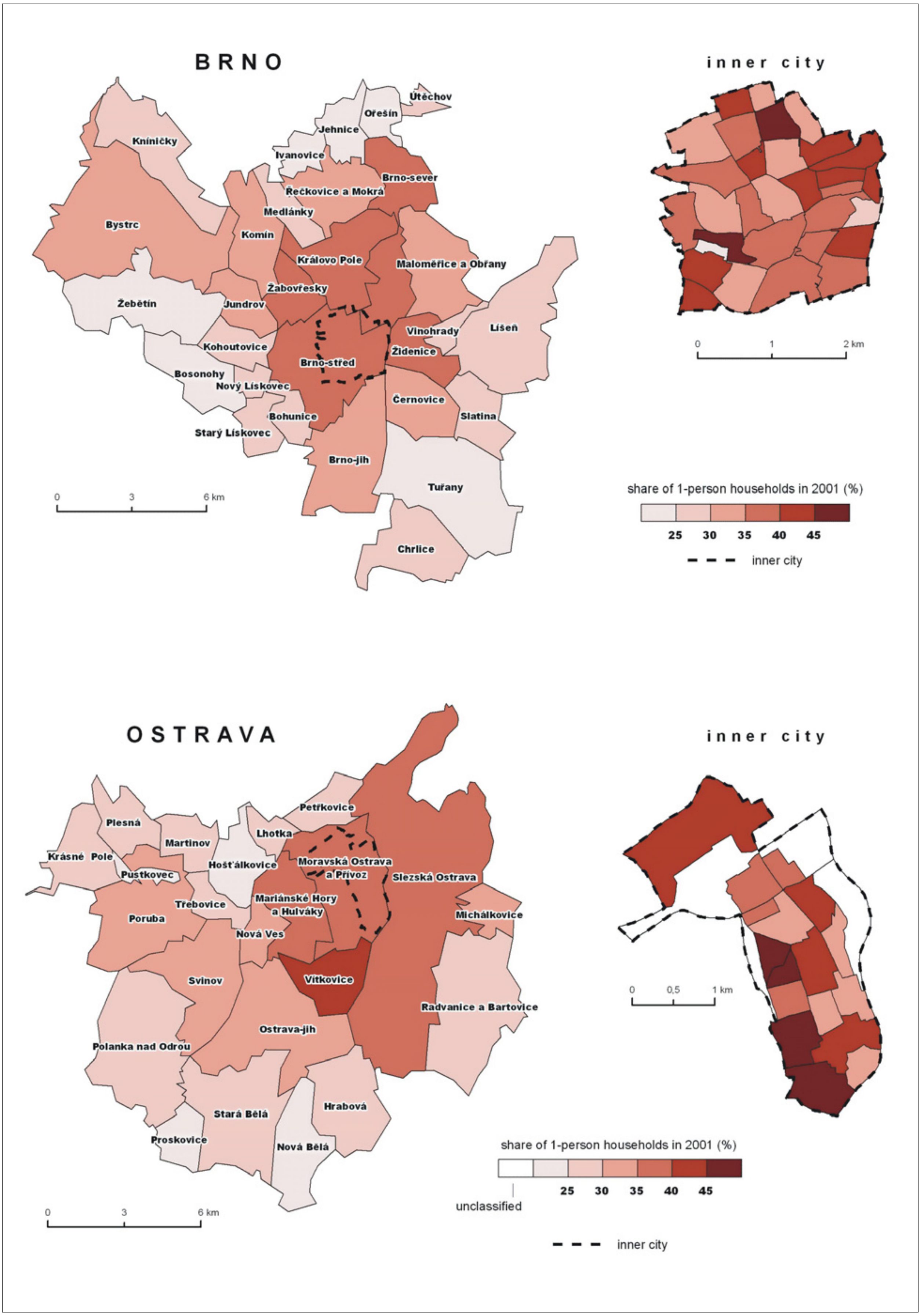

Fig. 7: Share of one-person households in Brno and Ostrava in 2001
Source: Census 2001 (Czech Statistical Office, www.czso.cz)

5. Summary

The outputs of the research focused on selected socio-demographic processes connected with the second demographic transition in the territory of Brno and Ostrava in the period after 1989. Not only have been identified similar trends in the two studied cities but also very important and significant differences. Almost during the whole period after 1989, depopulation trends prevailed in the territories of the examined cities Brno and Ostrava. The population decline was caused not only by the change of demographic behaviour (the decline in fertility influenced the natural population decrease) but also by significant changes of migration flows. The intensity of depopulation was higher in Ostrava than in Brno, because net migration in Ostrava was influenced by difficulties of economic transition (closedown of mines and decrease of production in heavy industries). Nevertheless, both cities were losing population due to migration and emigrants outnumbered immigrants in a larger part of the studied period. From a spatial point of view, depopulation was more intensive in both inner cities than in the other urban districts (especially due to the influence of housing stock commercialization) with only the exception of a few basic settlement units with huge concentrations of social problems.

At the same time, an intensified population ageing process was under way in both cities, the most intense being in old residential areas where almost no housing development occurred. The proportion of young people is higher in Ostrava than in Brno and it might have been influenced by the support given to the immigration of younger people, usually with relatively lower qualifications in the period of socialism before 1989. Within the scope of a more detailed examination of city centres, specific spatial differences were noticed particularly in districts with a larger share of Roma people (more young people), which we can mark as common characteristics of inner cities in both examined cities. More problems related to population ageing were detected in Brno – at the end of 2007, almost 17% of inhabitants were over 65 years. In this context, investment into social services and financial security has to be considered in the near future. The share of one-person households increases in both cities (relatively more rapidly in both inner cities), nonetheless the share itself is not comparable to trends in similar western European cities. We come to the conclusion that the second demographic transition in Brno and Ostrava is certainly under way, but not at such a rate as in western European cities. However, the experience gained from the research of demographic processes in western European cities can help us in the creation of detailed scenarios and prognoses that will help to predict demographic trends in Czech cities in the future.

Acknowledgement

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URBAN REVIVAL IN THE POLISH SPECIALIST LITERATURE

Krzysztof ROGATKA

"It's wonderful when people are proud of their city but it is even more wonderful when the city can be proud of its people." ***Abraham Lincoln (1809–1865)***

Abstract

The aim of this article is to review and assess the Polish specialist literature on urban revival, i.e. all actions undertaken to revitalise and restructure urban areas. The discussion of this issue was based on the classification of the specialist literature concerning urban revival into five thematic groups: socio-demographic, spatio-functional, economic, environmental and cultural.

Shrnutí

Obnova měst v polské odborné literatuře

Cílem článku je shrnout a zhodnotit polskou literaturu týkající se obnovy měst – tedy všech jevů týkajících se revitalizace a restrukturalizace. Diskuse na toto téma je založena na klasifikaci a rozdělení odborné literatury do pěti tématických skupin: socio-demografické, funkčně-prostorové, ekonomické, environmenální a kulturní.

Key words: *Poland, city, urban revival, revitalisation, restructuring, gentrification*

1. Introduction

The issue of urban revival is becoming increasingly popular in the world as well as in Poland where it is particularly up-to-date. This is because World War II left lots of cities damaged, and these were cities which became a base for radical economic changes that took place in numerous states of the world.

Intensive and uncontrolled development of cities after WWII led to significant urban sprawl as well as to taking over new green fields. The Earth has become an urban planet and there is a need to find ways to create and efficiently manage the urban space, urban and architectural structures and, most importantly, the population. Considering the above, the solution seems to lie in an effectively managed urban revival, which should include socio-demographic, spatio-functional, economic, environmental and cultural aspects.

At the turn of the 19^{th} and 20^{th} centuries, most urban areas were taken by industries and their infrastructure as well as by living quarters for people employed in factories. Looking at this issue from the perspective of market economy, factories, warehouses, depots and other premises from the times of both intensive industrialization and socialism tend to have one common characteristic. It is their very good location within the spatio-functional layout of cities which, as a result, stimulates a great interest in those areas.

The crisis of the 1980s, a new socio-economic situation and political changes led to restructuring and modernising numerous aspects of the economy in Poland. The consequence of these changes was close-down of factories and abolishment of many institutions. Thus, urban areas acquired derelict buildings and areas, which have lost their functions, such as industrial, seaport or military ones (W. Rakowski, 1980; S. Kaczmarek, 2000, 2001; B. Jałowiecki, M. Szczepański, 2002; A. Lisowski, 2005; B. Jałowiecki, 2008a, b).

As a result, geographic research on the development and restructuring urban areas in Poland dealt after 1989 with the issues of activation, restructuring, revitalisation and gentrification of the urban areas which had lost their previous functions and thus might undergo revival processes. Geographers, urban planners, architects, sociologists, ecologists, councillors and managers of urban revival focused their attention on:

- post-industrial areas (factory halls, depots, warehouses and plots),
- communication objects and machinery (railway and seaport areas and objects),
- post-military areas (barracks, fortifications and firing grounds),
- housing estates, built-up quarters, streets, districts, selected groups of buildings (mainly located in the inner city).

It must be emphasized that urban revival has become an important issue which is being discussed by both scientists and practitioners. It is due to the fact that negligence in this matter might impair competitiveness among European and world cities.

There are a number of terms which refer to remedial and regeneration processes in quarters, streets, districts and whole cities, such as revalorisation, restructuring, renewal, revitalisation, reuse and gentrification. Even though these terms are often used interchangeably or wrongly, they all refer to urban revival processes.

Due to the limited space of this publication as well as complexity and multitude of issues, the article focuses on selected dimensions connected with the urban revival, such as socio-demographic, spatio-functional, economic, environmental and cultural aspects.

2. Studies on urban revival – general issues

The issues of the revitalization, revival and restructuring of cities are often and widely discussed by researchers from various countries. We may indicate some aspects and trends presented in the literature. Moreover, the Polish research refers to European and world's studies. Above all, following aspects should be mentioned:

a) socio-demographic (P. Hall, 1990; C. Hamnett, 1996; D. Lay, 1996; Sassen S., 2001),
b) spatio-functional (P. Bagguley, J. Mark-Lawson, D. Shapiro, J. Urry, S. Walby, A. Warde, 1990; P. Hall, 1990; T. Hall, 1997),
c) economic (J. H . Johnson, 1965; J. Jacobs, 1969; D. Lay, 1993; P. J. Taylor, 2004),
d) environmental and cultural (N. Lewis, C. Graham, 1992; S. Sassen, 2001; M. Pacione, 2005).

All specified aspects emphasize that it is crucial to economize the urban space and to try bringing each part of it into cultivation. Summing up, urban revival is an appropriate remedy for space deficiency and for reaching a spatial order.

As the transformation and revival of urban areas is also a multi-aspect and multidimensional issue, it remains within the interests not only of geographers but also of a number of other specialists, including sociologists, architects, economists, town-planners, philosophers, naturalists and historians. Their studies are monographs, elaborations of one or more issues, as well as syntheses or holistic approaches.

In Poland, the transformation of both degraded urban areas and whole towns represents an important issue of urban geography and settlement geography. Urban studies are experiencing a specific renaissance, which is connected with a local and regional aspect of geographical studies (K. Dziewoński, 1953, 1956; J. Ziółkowski, 1965; B. Jałowiecki, 1972, 2008a; M. Kiełczewska-Zalewska, 1972; P. Korcelli, G. Węcławowicz, 1982; J. Regulski, 1986; S. Liszewski, 1988, 1994, 1995, 1997a, b, c, 2001, 2008a, b, c; G. Węcławowicz, 1988, 1999; S. Nowakowski, 1988; R. Domański, 1989, 1999, 1993; J. Wódz, 1990, 1991; W. Maik, 1992, 1993;

Z. Chojnicki, 1992; E. Kaltenberg-Kwiatkowska, 1994; S. Kaczmarek, 1996, 1997, 2004 b; P. Lorens, D. Załuski, 1996; J. J. Parysek, J. Kotus, 1997; Z. Zuziak, 1999; D. Ptaszycka-Jackowska, 2000; B. Jałowiecki, M. Szczepański, 2002; J. J. Parysek, 2006 a, b; D. Szymańska, 2007, 2009; B. Jałowiecki, W. Łukowski, 2007). These research studies are often of both general and multidimensional character.

The base of modern geographical thoughts on rejuvenation and transformation of derelict urban areas is found in the papers published among others by W. Czarnecki (1960); J. Goryński (1982); J. Gryszkiewicz, S. Kaczmarek, S. Liszewski (1989); K. Dziewoński (1990); R. Domański, T. Marszał (1995); M. Kochanowski (1996); R. Domański (1997, 2000, 2002); J. J. Parysek, H. Rogacki (1998); W. Pęski (1999); Z. Ziobrowski, D. Ptaszycka-Jackowska, A. Rębowska, A. Geissler (2000); J. J. Parysek (2005, 2006b); A. Starzewska-Sikorska (2007). They indicate it is necessary to transform the urban space radically, which is mainly understood as the levelling of disproportions in living standard and quality of life and upgrading town management and urban aesthetics. Moreover, P. Korcelli (1974); J. J. Parysek and T. Stryjakiewicz (2004), and R. Domański (2002) paid attention to a global aspect of economic and spatial changes, which are reflected on a local scale, mainly in town and cities. As a result, geographers should become more involved in the preparation of scenarios for the further development of cities and regions which take into consideration global trends (such as urban revival in the context of sustainable development, space recycling and urban ecosystems).

Urban revival, including all revitalisation processes, shows a number of basic aspects. Each of them has its own features, which influence directly and indirectly the course and effects of the process in a given area. Thus, as mentioned above, the analysed phenomena can be considered in their socio-demographic and spatio-architectural-functional aspects, as well as in those which are significantly influenced by economic, environmental and cultural aspects.

2.1 Studies on urban revival – the socio-demographic aspect

For a number of years scientists have been concentrating on social processes taking place in the urban space. There are numerous papers worldwide, which tackle social aspects of the urban revival. However, in Poland, this issue has not been so widely regarded. On the one hand, this might be caused by novelty and complexity of this aspect of modern urban space. On the other hand, however, this might be caused by a lack of proper statistical data available.

Political changes intensified a number of socio-economic and spatio-functional processes. In accordance with G. Węcławowicz (2001), three basic social groups can be delimited, which, like actors, play roles on the stage called a city. These are elite and middle classes and the poor, and they, in a way, fight for space with one another. The repair processes should mitigate all the negative social, spatial and economic effects of urban revival. As a result of these undertakings, living quarters, workplaces and recreation areas for all inhabitants of a town should be created.

The society, mainly through local communities, has a double role in the revitalisation processes. It is due to the fact that a local community initiates, plans, controls and monitors these processes, but it is also influenced by them. Urban revival introduces new functions to the area which can either be addressed to inhabitants of a given district or quarter or to people from the outside of it. As a result, according to S. Kaczmarek (2001) and B. Domański (2000a, b), conflicts between the 'old' and 'new' space users can arise. Such situations should be avoided as the social integration is one of leading social goals of the urban revival. On the other hand, however, social expectations and requirements of local communities as well as the pressure exerted by them represent the main factor which brings dynamics of the revival processes.

The areas undergoing the above processes belong to the so-called problematic and pathologic areas, where social situation is far from the generally accepted standards. The issues of social marginalisation and exclusion were underlined by A. Bukowski, B. Jabłońska, and M. Smagacz-Poziemska (2007). In accordance with their definition, social exclusion means 'not following a common and socially accepted way of life, or detouring from it'. Similar topics are also found in the papers by L. Frąckiewicz (2004); A. Gawkowska, A. Kościański, P. Gliński (2005), while G. Węcławowicz (2001); A. Zborowski and M. Deja (2009) deal with the assessment of the intensity of the phenomena of social degradation, poverty, unemployment as well as social segregation and polarisation in areas under urban restructuring. The authors pay attention to the fact that unemployment, including long-term unemployment, is the leading factor responsible for poverty and, as a result, for social exclusion. According to B. Jałowiecki (1980, 1988, 2000); J. Wódz (1989); I. Sagan (2000); J. J. Parysek (2006); A. Radziński (2007); D. Kotlorz (2008); R. Jeż (2008); A. Barteczek (2008); K. Skalski (2008); and A. Zborowski and M. Deja (2009), urban revival counteracts unemployment and, as a result, poverty and pathology. This is due to the fact that new, interesting workplaces are created in the revitalised parts of a town or city.

Thus, if quickly introduced and well directed, the revival processes can counteract pauperisation and mitigate social degradation of districts, quarters or whole towns. According to J. Szczepański (1981); J. Drążkiewicz (1982); M. Jerczyński, A. Gawryszewski (1984); K. Skalski (1996, 1998); J. Słodczyk (2000); Z. Ziobrowski (2000a, b); A. Lisowski (2001); B. Jałowiecki (2003); I. Sagan, M. Rzepczyński (2003); G. Węcławowicz (2003); I. Jażdzewska (2004); S. Kaczmarek (2004a); I. Sagan (2004); M. Dymnicka (2005); B. Jałowiecki, A. Majer, S. M. Szczepański (2005); J. Kotus (2005); A. Zborowski (2005); J. Słodczyk, E. Szafranek (2006); and W. Siemiński (2009a), the overriding concern of repair processes in urban areas is the society. It is due to the fact that the society itself is the main addressee of the revitalisation idea, which should follow the convention of a social dialogue.

2.2 Studies on urban revival – the spatio-functional aspect

The next aspect of processes leading to the urban revival is connected with the spatial order (J. J. Parysek, 2003; T. Topczewska, 2009). This problem is reflected in numerous scientific papers, which is possibly the effect of a relatively easy access to field data as well as the application character of the research.

Many publications on this topic stress that the integration of newly occupied areas with a town or city, that is the creation of a specific urban continuum, remains the main spatial, architectural and functional premises for urban revitalisation (P. Korcelli, 1974; R. Domański, 2002). Considering the above, restructuring urban space is definitely the most radical and spectacular manifestation of repair undertakings. New facades and renovated buildings, modernised and adapted factories, depots and warehouses, modern communication systems, well maintained green areas and interesting forms of space utilisation create totally new and changed urban space. In accordance with W. Czarnecki (1960); H. Syrkus (1976); S. Liszewski (1988); W. Maik (1992); B. Jałowiecki (1999); B. Domański (2000a, b); J. Słodczyk (2000); K. Skalski (2000); A. Rębowska (2000); S. Kaczmarek (1999, 2001); D. Załuski (2001); G. Gorzelak (2003); C. Wawrzyniak (2003); I. Jażdżewska (2004, 2006); J. Gorgoń, A. Starzewska-Sikorska (2007); A. Wolaniuk (2008); and K. Mazur-Belzyt (2008), attractive urban interiors, squares, frontages and parks which take place of the disappearing fences, rubble, walls and courtyards are the manifestations of urban revival.

The spatio-architectural-functional aspect of urban revival can be considered both in its urban and architectural approach. According to K. Skalski, 1996, 2000; Z. Zuziak, 1996; A. Baranowski, 1998; A. Geissler, A. Romiński, 2000; Z. Ziobrowski, 2000a, b; R. Ast, 1999, 2001, just to name a few, the urban approach to a reconstruction of a whole or part of a town or city means such a transformation of the area so as it could meet the new needs designed for it during the revitalisation process. It is crucial, however, that the previous state of the area will have been well preserved too. Such transformations include, among others, spatial, functional and very important infrastructural changes. In this form, the urban revival means creating new buildings, introducing changes in the communication and infrastructural systems as well as modernisation of the existing buildings. The architectural approach, on the other hand, means introducing innovations and improvements into the existing building (construction elements and installations). As a result of urban and architectural activities, a given city area acquires new functions and aesthetics, which often become the city's showcase. The above issues were widely commented on in the papers by the following authors: S. Kaczmarek, 2001; J. Słodczyk, 2001; L. Czarniecka-Markindorf, 2002; S. J. Kozłowski, 2005; D. Stawasz, M. Turał, 2006; and H. Domański, 2007, just to name some of them.

2.3 Studies on urban revival – the economic aspect

A lot of papers (W. Maik, 1995; P. Korcelli, 1996; R. Domański, 1997; J. Słodczyk, 2000) pay attention to the fact that spatio-functional and social changes influence the economic situation of the rejuvenated part of a town or city and, consequently, the entire urban organism. As J. J. Parysek (2006a) indicates that all repair processes within the urban area lead to economic boom as the newly created space brings new opportunities such as new jobs and new places for economic activity in retail, services and production. As M. Pieniążek (2007) suggests, the specificity of revitalisation and restructuring processes leads to the situation where traditional branches of industry are replaced with advanced services. Furthermore, the paper by B. Sieracka-Nowakowska and R. Nowakowski (2005) indicates that degraded urban areas are becoming increasingly used as places convenient for the development of science, technology and Research & Development (R&D) services. Moreover, the papers by M. Jerczyński, 1973; W. Rakowski, 1980; Z. Ziobrowski, 1998; R. Domański, 1997; A. Harańczyk, 1998; S. Kaczmarek, 1999; B. Domański, 2000; S. Liszewski, 2001; T. Stryjakiewicz, 2002; M. Piech, 2004; Z. Zuziaka, 1996; and W. Siemiński, 2009a, b indicate that modern industry needs different surroundings and structures than classical industry. Scientific and technological advancements have triggered the development of economy based on innovations, ICT and highly qualified human capital. Industrialisation was an unavoidable factor, which initiated the processes of urbanisation, development, transformation and, in consequence, the revitalisation of urban structures. This issue was tackled in the papers by J. Drążkiewicz (1982); B. Domański (2000a); I. Sagan (2000); J. Słodczyk (2000); D. Szymańska, A. Matczak (2002); W. Skrobot (2002); T. Biliński, D. Kłosek-Kozłowska, and K. Skalski (2003). Other researchers (I. Fierla, 2004; K. Mazur, 2005; A. Pancewicz, 2005; Z. Chojnicki, T. Czyż 2006, 2008; T. Stryjakiewicz, 2008; P. Churski, 2008; W. Siemiński, T. Topczewski, 2009) conclude that the primacy of industrialisation over urbanisation resulted in the fact that localisation and development of factories were the main factors leading to urbanisation. According to R. Domański (2002), J. J. Parysek and T. Stryjakiewicz (2004), ICT has globalised the economy. As a result, some aspects of human activity, including industry, have been transferred while others have been degraded. Globalisation, high technologies and the so-called new economy have changed the role of the traditional location factors. The importance of physical distances has declined, whereas the meaning of the 'soft' and institutional factors for both location and development has increased. The economy of most of the More Economically Developed Countries (MEDCs) is undergoing the post-industrial phase where the role of industry has changed significantly. Restored, revitalised or restructured towns and cities transformed into development and growth hubs are well suited for challenges of the modern economy.

2.4 Studies on urban revival – the environmental aspect

One of significant aspects of the urban revival is represented by ecological actions with their main target in revitalization and restructuring processes, which ensure the progress of biologically active areas. Moreover, it causes the growth of flora and fauna biodiversity in cities and its suburbs. In addition, these actions contribute to protect typical species nesting in the locality. Aforementioned efforts, stressed by several researchers (Ziobrowski, D. Ptaszycka–Jackowska, A. Rębowska, A. Geissler, 2000; S. Kaczmarek, 2001; A. Starzewska–Sikorska, 2007), influence the restoration of ecological balance and help to upgrade aesthetic and artistic qualities of urban landscapes. Consequently, these aspects improve the quality of the city life.

Pro-ecological initiatives being pursued among rural areas within revitalization processes are aimed at a usage of new, energy-saving, environment-friendly substances and technologies. Therefore, numerous researchers (W. Maik, 1992; K. Janas, W. Jarczewski, W. Wańkowicz, 2010) point out that all building renovations, thermo-modernizations, new installations, solar panels, ecological sewage-treatment plants are elements that essentially contribute to the pro–environmental restoration of the urban system.

Considering the urban revival we observe that study literature (J. J. Parysek, J. Kotus, 1997; A. Baranowski, 1998; J. J. Parysek, 2005; S. Bródka, I. Markuszewska, 2009) is significantly focused on problems with the environment in former industrial areas and also on possibilities of its reclamation.

What causes negative environmental changes is industrial activity (changes in terrain morphology, disruption of hydrological processes, reduction of flora and fauna species). Therefore, after the close-down of production and exploitation processes, it is essential to commence restoration of environmentally ruined areas. It should lead to the revival of the natural, cultural and usable (practical) value of the above mentioned areas.

2.5 Studies on urban revival – the cultural aspect

The spatial, economic, social and environmental aspects of urban revitalisation cannot go without the cultural aspect (treated here as tradition). It is a combination of the earlier mentioned four aspects and a kind of synergy between them.

The awareness of the necessity to save valuable urban objects was first expressed in England where industry developed first. There, the oldest objects of the industrial and technological revolution are crucial for the entire Europe and treated as national heritage. In the 1980s, the process of saving the English monuments began, and the very idea of their conservation, revitalization and restoration gained popularity. Such an approach can also be seen in Polish cities and successful examples of repair processes include Łódź, Wrocław and Poznań, just to name a few (B. Domański, 2000b; S. Kaczmarek, 2001; P. Lorens, 2001; T. Kaczmarek, 2001; A. Billert, 2006; S. Belniak, 2009).

Urban areas undergoing revitalization processes remain a kind of witnesses of the old times and as such they should be protected in a professional way. Industrial halls, mining machinery, ports, docks with warehouses and others express tradition in human activity and a reminder of the technological development. They are urban monuments and speechless witnesses of history. Such issues were reflected in the papers by, among others, Z. Zuziak (1997, 1998); T. Markowski (1999); A. Lisowski (2002); M. Dymnicka, (2005); M. A. Murzyn (2006, 2007); and M. Madurowicz (2007). Tradition is becoming a kind of a thread of transformations and changes which lead to the development of a new and functional place, necessary for the contemporary people but with the respect for the past. Consequently, we may expect new research on this matter in the near future.

Another up-to-date research problem discussed in the specialist literature and connected with urban revival processes is gentrification. Although this issue has been widely discussed in the foreign literature, in Poland it is still regarded as new, innovative and not widely known. However, this situation is changing as indicated in articles by A. Lisowski (1999); S. Kaczmarek (2001); E. Szafrańska (2008); and A. Jadach-Sepioło (2009a, b).

Gentrification as a 'market renewal process' aims at upgrading the area or the city quarter. This term has been used in the specialist literature since the 1960s and comes from an English word 'gentry'. It describes the process of an influx of new urban 'gentry' to the city centre. As a result, the character of the district changes and social succession takes place when the rich population forces the poor to move out from the area undergoing gentrification (S. Kaczmarek, 2001; D. Szymańska, 2007; E. Szafrańska, 2008). This term is tightly interwoven with the revitalization processes in towns and cities and is treated as a side effect of revitalization. However, gentrification can also take place irrespectively of other revival processes. Differences between the discussed processes refer to planning, demographic, social, economic and cultural factors (see Fig. 1).

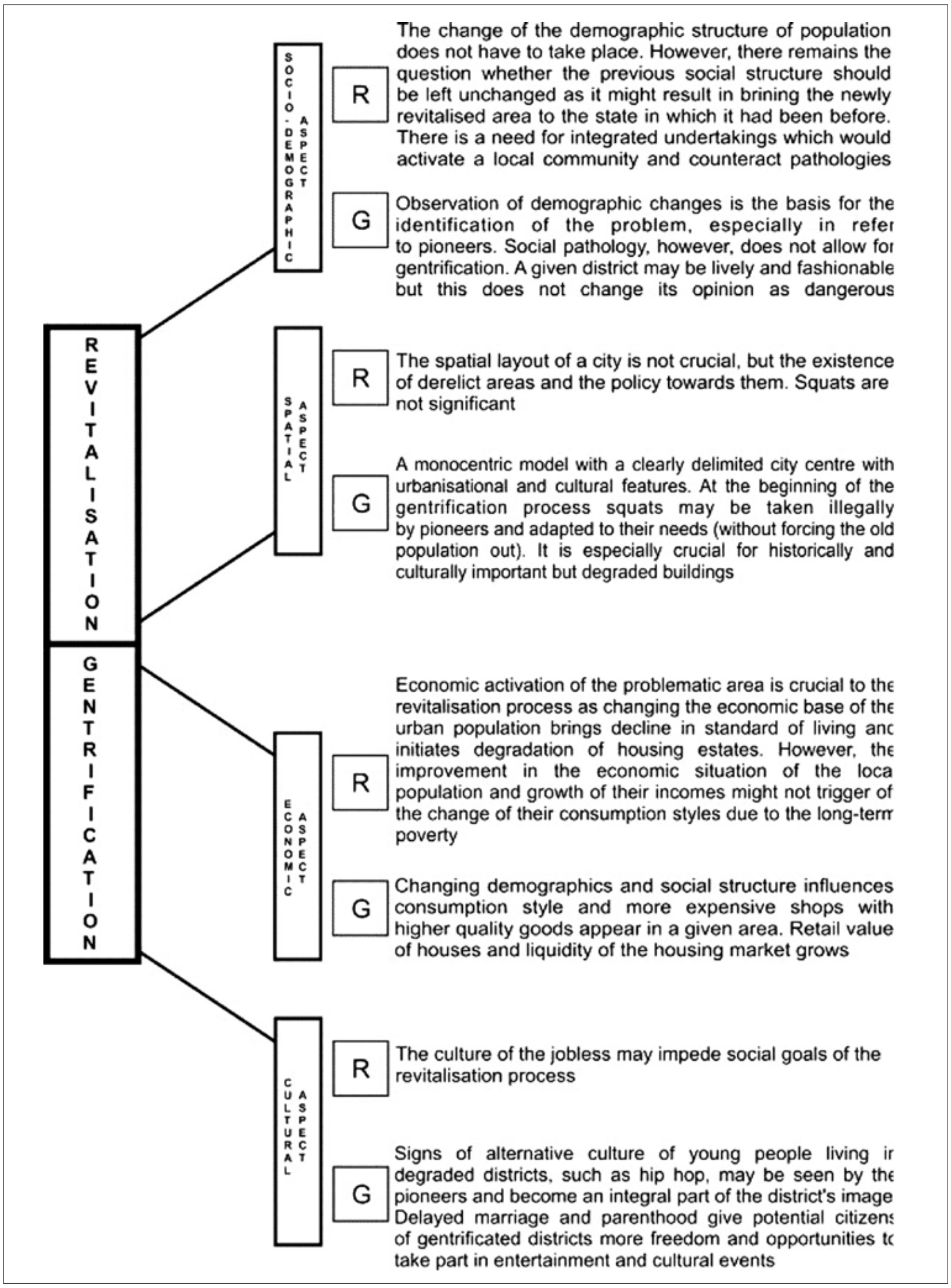

Fig. 1: Revitalisation and gentrification – their main aspects and differences
Source: Compiled by the author on the basis of A. Jadach-Sepioło, 2009a

The above review of the specialist literature indicates that the knowledge of relation between the revitalization and gentrification processes is not complete and needs further research. These phenomena are relatively new in processes shaping the structure of modern towns and cities (A. Lisowski, 1999; A. Jadach-Sepioło, 2009; J. Grzeszczak, 2010). Therefore, it is necessary to study the development and evolution of these issues.

3. Final remarks

The publishing market has recently been enriched with a number of new papers on the analysed issues. This article presents and tries to asses only a small part of the Polish specialist literature. Moreover, numerous works of Polish researchers including geographers often discuss the processes of urban transformation in socio-economic systems yet without a clear reference to the terms of urban revitalization, gentrification or revival.

Certain deficiency is recorded in the number of papers dealing with the quantification of the specific cases of urban revival. As A. Lisowski (1999) indicates, this might be connected with the multi-aspect character or novelty of the issue. It is also significant that the analyzed processes have a strong social character and thus it is difficult to quantify them. However, there is a large number of papers dealing with the spatio-functional aspect of urban revival. This can be conditioned by the fact that the inflow of the EU funds has added dynamics to the revitalization processes. As a result, towns and cities have gained restructured spaces that are analyzed, studied and researched. Additionally, the issue of urban revival in Poland follows the world trends, which refer to the socio-economic and functional changes in the cities worldwide.

Urban revival remains an important scientific topic of geographical research as it refers to time and space as well as to changes that take place in urban centres of diverse functions, character and size. On the other hand, however, urban revival is classified as interdisciplinary, or even multidisciplinary, which increases the complexity of the analyses and mounts difficulties in the holistic approach to the issue.

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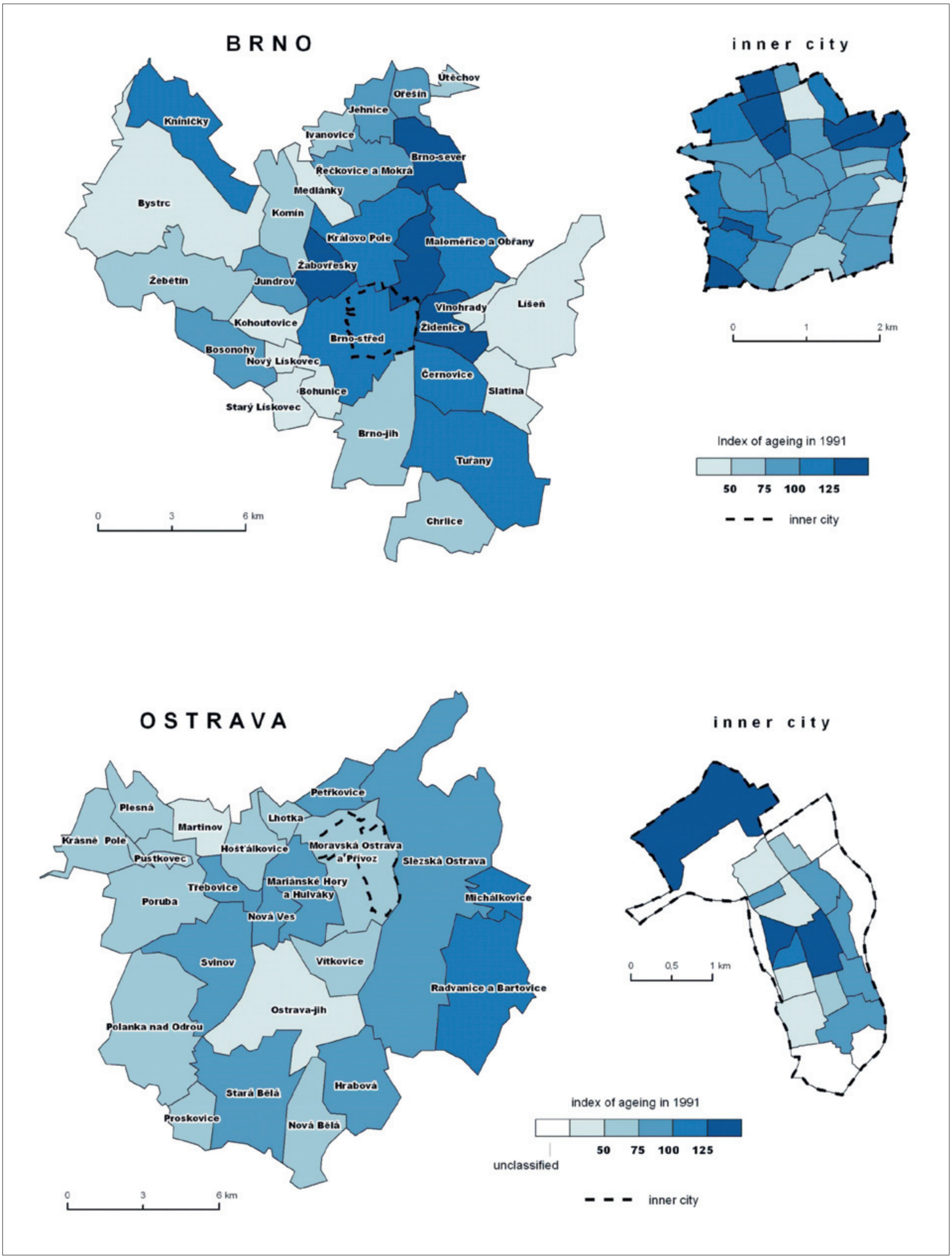

Fig. 4: Age index (65+ / 0–14) for Brno and Ostrava in 1991
Source: Census 1991 (Czech Statistical Office, www.czso.cz)

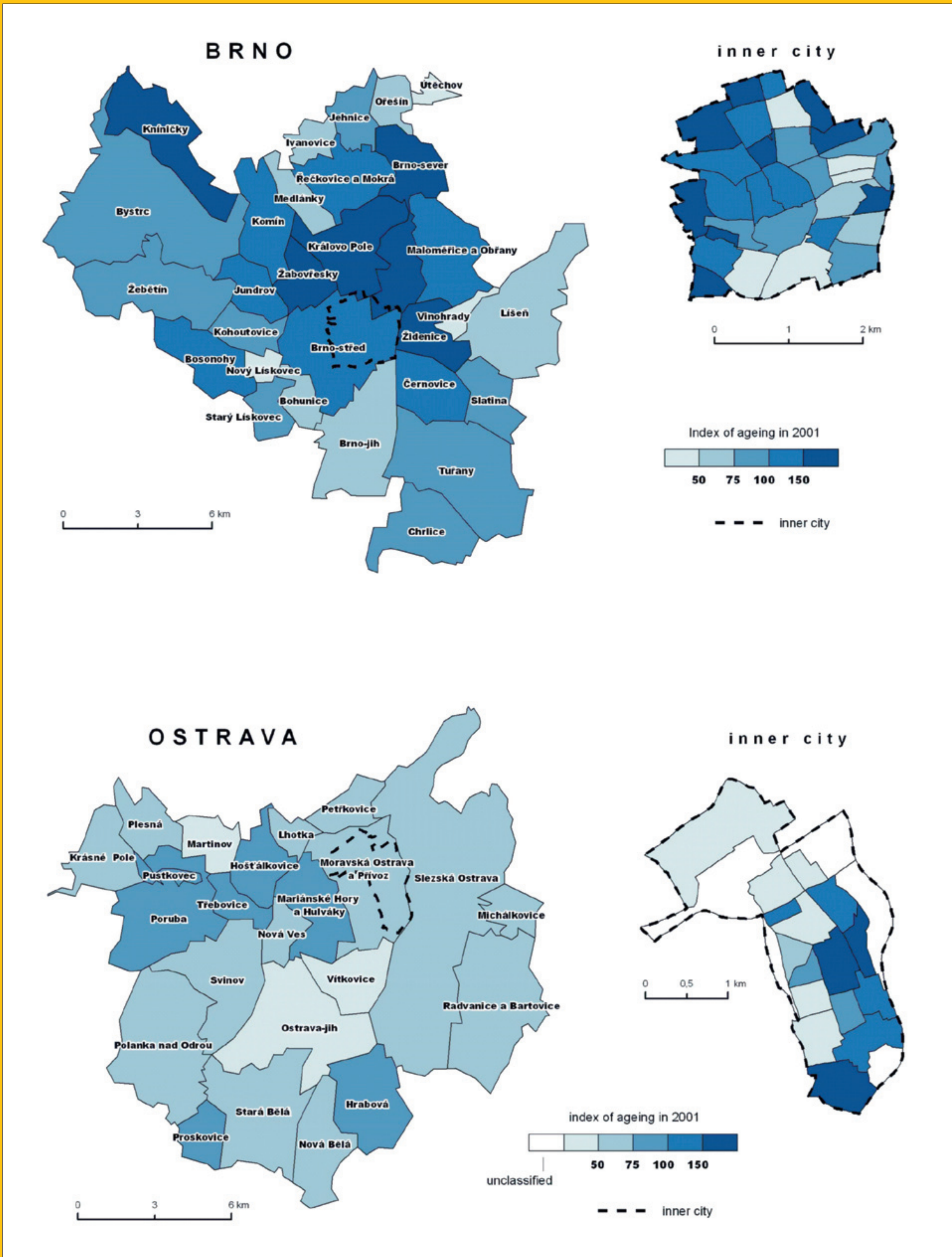

Fig. 5: Age index (65+ / 0–14) for Brno and Ostrava in 2001
Source: Census 2001 (Czech Statistical Office, www.czso.cz)

Illustration related to the paper by T. Krejčí, S. Martinát and P. Klusáček