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Applications of stable carbon isotopes in soil science with special attention to natural ^{13}C abundance approach

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Abstract

Since the invention of the isotope ratio mass spectrometer in the late 1930s, isotope analysis has shed light on many key processes in the Earth's ecosystems. Stable isotope analysis was first applied in the field of chemistry and geochemistry in the 1940s, while the use of isotopic fractionation for various biochemical reactions was elaborated later. The knowledge gained from isotope research led to a better understanding of the dynamics of the biosphere and to the more efficient study of interactions between the geosphere and biosphere. In soil research, stable isotopes are ideally suited to provide a wider insight into the element cycles in soil ecosystems. Stable carbon isotopes, in particular, have been in the focus of soil research, since soil organic matter (SOM) plays an important role not only in soil fertility, soil water management and many other physical, chemical and biological soil functions, but also in the global carbon cycle. If processes connected with these soil functions are isotopically labelled with stable carbon isotopes, the key reactions of C input, exchange and output in the soil and other soil organic matter functions can be studied accurately. The ^{13}C abundance approach is one of the useful methods applying natural stable carbon isotope differences in the atmosphere-plant-soil system to track the stability of organic carbon in these reservoirs. The turnover of SOM, particularly the rate of decomposition and the partitioning of C between the different soil CO_2 efflux sources are in the focus of soil science research, which can be studied in detail with the help of natural ^{13}C abundance method. Thus, analysing the isotopic composition of CO_2 exchange between the soil and the atmosphere not only helps to gain more information about the impact and role of SOM and its various forms but also to predict ecosystem responses to global changes.

Keywords: stable C isotopes, ^{13}C natural labelling, soil organic carbon turnover, isotope fractionation

Introduction

The application of stable isotope analysis has proved to be an extremely useful tool for tracking various changes in the Earth's systems. Since the discovery of isotopes in the 1910s, stable isotope geochemistry has provided essential information for geosciences, first for chemistry and geochemistry and later for biochemistry and ecology (Dawson, T.E. and Siegwolf, R.T.W. 2007). With the help of stable isotopes, paleo-environmental reconstruction became an achievable tool (Epstein, S. *et al.* 1953), as did the study of the atmosphere and the hydrological cycle via the isotopic signature of precipitation (Dansgaard, W. 1964). Stable isotopes also help the more precise identification of extinction events (Pálfy, J. *et al.* 2001). These are just a few examples of the possible application of stable isotopes in geochemical questions. Today, stable isotope analyses cover almost the entire spectrum of geoscience research and in some areas their application is mandatory (Deméný, A. 2004).

The carbon isotope composition of organic and inorganic compounds alters in the course of exchange processes in the vegetation-soil-atmosphere cycle, leaving an isotopic imprint on plant, soil and atmospheric carbon pools and fluxes (Werner, C. *et al.* 2012). These isotopic imprints allow, for example, the tracking of newly assimilated C incor-

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porated in plants, then migrating to the soil, stored within the soil ecosystem or lost to the atmosphere (Brüggemann, N. *et al*. 2011). Paleo-environmental studies (Schwartz, D. *et al.* 1986; Cerling, T.E. *et al.* 1989; Fox, D.L. and Koch, P.L. 2004; Barta, G. *et al.* 2018) use stable carbon isotopes in soils or paleosols to track past changes in vegetation and climate. Stable carbon isotope methods related to landscape evolution, land use change and erosion studies (Paul, S. *et al.* 2008a; Häring, V. *et al.* 2013; Alewell, C. *et al.* 2016; Brandt, C. *et al.* 2016, 2018) make it possible to trace the origin and stability of carbon in different systems during diverse processes.

Today, stable isotope information permits scientists to address issues that seemed intractable using other methods. The stable isotope data generated with these methods have provided insights into a wide range of complex processes on temporal and regional scales from seconds to millennia and from cells to net ecosystem flux partitioning (Dawson, T.E. *et al.* 2002; Dawson, T.E. and Siegwolf, R.T.W. 2007).

This review provides the theoretical background of stable isotope research, using examples of major processes resulting in carbon isotope fractionation to illustrate various types of isotope fractionation and highlighting the stable carbon isotope variation in the Earth's main reservoirs, focusing in particular on soil ecosystems. It details the applicability of stable carbon isotope research in soil sciences, with special attention to the ^{13}C natural labelling approach. The natural abundance of stable carbon isotopes has been widely used to probe the turnover of SOM and to differentiate the diverse sources of CO_2 efflux from the soil. These results provide a clearer picture of the fate of organic carbon in the vegetation-soil-atmosphere cycle.

Isotope nomenclature and fractionation

Determining the absolute abundance of isotopes is difficult, because absolute variations in isotopic abundance based on physical and biological factors are small (to the order of a few percent) (Ehleringer, J.R. and Rundel, P.W. 1989), so relative isotope abundance is conventionally calculated as follows:

$$R = \frac{rare\ isotope}{abundant\ isotope}, \quad (1)$$

where R is the ratio of the *rare isotope* to the *abundant isotope*. The ratio R of a sample is generally compared to that of a known standard material, which provides high precision and repeatability over the long-term. Because of the small variations present in nature between the isotopic compositions of the sample and the standard material, the ratios are expressed using the conventional δ notation, introduced by Craig, H. (1953), in parts per thousand:

$$\delta\ (‰) = \frac{R_{sample}}{R_{standard}} - 1\ (\text{x}\ 10^3) \quad (2)$$

The unit of δ is "‰" or "permil" (also per mill).

The worldwide standards for the six conventional elements are V-SMOW (Vienna-Standard Mean Ocean Water) for H, V-PDB (Vienna-PDB, a replacement standard for the original calcium carbonate found in *Belemnitella americana* in the Cretaceous PeeDee formation in South Carolina, USA) for C, AIR N_2 for N, V-SMOW for O, V-CDT (Troilite from the Canyon Diablo iron meteorite) for S and NBS-28 (quartz sand) for Si (Hoefs, J. 2009).

The basis for isotope geochemistry is the fractionation of isotopes, i.e. 'the partitioning of isotopes between two phases of the same substance with different isotope ratios' (Hoefs, J. 2009), which results in different isotopes of the same element having different distribution patterns in the environment. The fractionation factor (α) is the difference in the ratio of the product isotope ratio (R_p) to the reactant isotope ratio (R_R):

$$\alpha = \frac{R_P}{R_R} \quad (3)$$

In general, isotope effects are small, $\alpha \approx 1$, so it has become common practice in recent years to replace the fractionation factor α by the deviation of α from 1, referred to as the *ε-value*:

$$\varepsilon = \alpha - 1 \ (\times 10^3) \quad (4)$$

The *ε-value* represents the enrichment ($\varepsilon > 0$) or depletion ($\varepsilon < 0$) of the rare isotope in the product compared to the reactant isotope and approximates the fractionation in parts per thousand, making it similar to the *δ value* (Mook, W.G. 2001; Hoefs, J. 2009).

Isotope fractionation is often referred to as 'discrimination' in biological systems, meaning that specific enzymes discriminate against the heavier and favour the lighter isotope (Dawson, T.E. *et al.* 2002).

Isotope fractionation is caused by mass-dependent and mass-independent mechanisms, of which the latter is less frequent. Isotope exchange reactions (or equilibrium isotope distribution) and kinetic processes are the main mass-dependent processes.

Equilibrium isotope fractionation

The distribution of isotopes is controlled by the lowest energy state of the system (Ohkouchi, N. *et al.* 2015; Trumbore, S.E. *et al.* 2016). The energy state of a molecule is based differences in translation, rotation and vibration energy, among which differences in vibrational energy are predominant. Therefore, this is the source of isotope partitioning (Hoefs, J. 2009). The vibrational energy of a molecule depends inversely on the masses of the atoms in the molecule (Bigeleisen, J. 1965). As a consequence, isotopes partition differently for various types of chemical bonds and for the phases of the same molecule (e.g. for H_2O as vapour, liquid or ice). The heavier isotope prefers molecules with stronger bonds and phases with less entropy (e.g. a solid versus a liquid versus a gas) (Trumbore, S.E. *et al.* 2016).

Equilibrium isotope fractionation occurs in nature especially between the phases of the $CO_2 - H_2O - H_2CO_3 - CaCO_3$ system. One typical example is the isotope equilibrium between gaseous CO_2 and dissolved bicarbonate (HCO_3^-):

$$^{13}CO_{2(gas)} + H^{12}CO_3^- \leftrightarrow {}^{12}CO_{2(gas)} + H^{13}CO_3^- \quad (5)$$

In this fractionation the ^{13}R (see above) is 0.0111421 for CO_2 gas (g) and 0.0112372 for bicarbonate (b) at 20 °C (Mook, W.G. 2001), so the fractionation factors are $^{13}\alpha_{g/b} = 0.9915$ and $^{13}\varepsilon_{g/b} = -8.46‰$. *Figure 1.* illustrates the different *ε-values* for different phases of the $CO_2 - H_2O - H_2CO_3 - CaCO_3$ system. This figure also shows the temperature dependence of isotope fractionation. In general, isotope fractionation is higher at a lower temperature, while it becomes zero at a very high temperature, based on the different vibrational frequencies of the molecules (Hoefs, J. 2009).

Another example of equilibrium fractionation is the precipitation of calcium carbonate from water. In this case the heavier C isotope will partition into the calcium carbonate, which has fewer degrees of freedom because it is solid. The $\delta^{13}C$ of C in calcium carbonate will be enriched to a greater extent (~10‰)

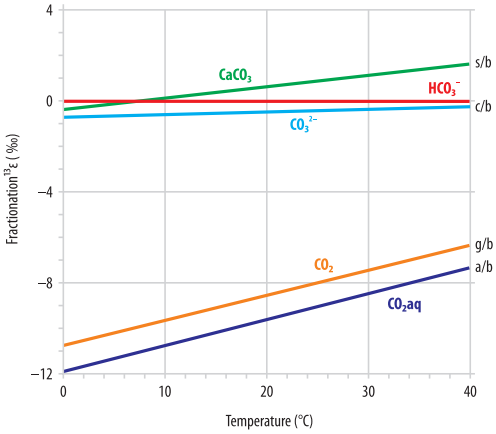

Fig. 1. Temperature-dependent equilibrium isotope fractionation for the different phases of the $CO_2 - H_2O - H_2CO_3 - CaCO_3$ system. – a = dissolved CO_2; b = dissolved HCO_3^-; c = dissolved carbonate ions; g = gaseous CO_2; s = solid carbonate. The different phases are shown with respect to dissolved HCO_3^-. *Source*: redrawn from Mook, W.G. 2001.

than that of atmospheric CO_2 in equilibrium with water from which the calcium carbonate is precipitated (Mook, W.G. 2001; Trumbore, S.E. *et al.* 2016).

Kinetic isotope fractionation

In comparison with equilibrium fractionation, kinetic fractionation occurs in non-equilibrium conditions when a reaction is irreversible, such as evaporation, diffusion, dissociation or biologically mediated reactions (Bigeleisen, J. and Wolfsberg, M. 1958; Hoefs, J. 2009; Ohkouchi, N. *et al*. 2015). Kinetic processes depend primarily on differences in the reaction rates of isotopic molecules: the lighter isotope will react and diffuse faster than the heavier isotope at a given temperature (Hoefs, J. 2009). As a consequence, the preferential enrichment of the lighter isotope is observed in the reaction products compared to the heavier isotope (Mook, W.G. 2001; Michener, R.H. and Lajtha, K. 2007; Hoefs, J. 2009; Ohkouchi, N. *et al*. 2015; Trumbore, S.E. *et al.* 2016).

One prominent example of stable C isotope fractionation is the process of photosynthesis:

$$6CO_2 + 6H_2O + light \rightarrow C_6H_{12}O_6 + 6O_2, \qquad (6)$$

where the ^{13}R of the reactant (atmospheric CO_2) = 0.9926, and the ^{13}R of the product (plant material) = 0.9724 (Trumbore, S.E. *et al.* 2016), giving fractionation factors of $^{13}\varepsilon = 0.9796$ and $^{13}\alpha = -20.4‰$.

Another kinetic process is the mineralization (bacterial decomposition) of soil organic matter to methane, resulting in an *ε-value* of about −55‰. Although natural processes are not purely kinetic or irreversible, they are often referred to as non-equilibrium fractionations (Mook, W.G. 2001).

Mass-independent fractionation

Some fractionation processes do not exhibit the mass-dependent effects described above. Mass-independent fractionation was observed in meteorites by Clayton, R.N. *et al.* (1973) with the use of oxygen isotope diagrams and was interpreted by Thiemens, M.H. (1999). In this kind of fractionation, Allègre, C.J. (2008) reported that isotope differences do not depend on the mass difference but on the symmetry of the molecule. Mauersberger, K. *et al.* (1999), however, demonstrated experimentally that it is not the symmetry of the molecule which is responsible for fractionation but the difference in its geometry. New research indicates that mass-independent isotope fractionations are more abundant than originally thought and serve as a novel form of the isotopic fingerprint (Hoefs, J. 2009).

Stable carbon isotope variation in the Earth's reservoirs

Of the three naturally occurring C isotopes, ^{12}C and ^{13}C are stable, representing 98.89% and 1.11% of the C atoms on Earth, respectively (Meija, J. *et al.* 2016). Both stable isotopes were originally created by nucleosynthesis in stars and their abundance has remained constant since their synthesis (Trumbore, S.E. *et al.* 2016). However, the relative abundance of stable C isotopes may vary in the Earth's various carbon reservoirs (atmosphere, biosphere, hydrosphere, lithosphere), resulting in naturally occurring variations greater than 120‰, from heavy marine carbonates ($\delta^{13}C$ values +20‰) to light methane ($\delta^{13}C$ values –110‰, *Figure 2*). The systematic differences in the $\delta^{13}C$ values of various carbon reservoirs have been known since the work of Nier, A.O. and Gulbransen, E.A. (1939).

Stable carbon isotope studies in soil science

Norman, A.G. and Werkman, C.H. (1943) conducted the first soil tracer study on ^{15}N-labelled soybean residues, examining their decomposition in the soil. Since then many types of research have used tracers to track the fate of SOM constituents and dynamics in soils. Stable

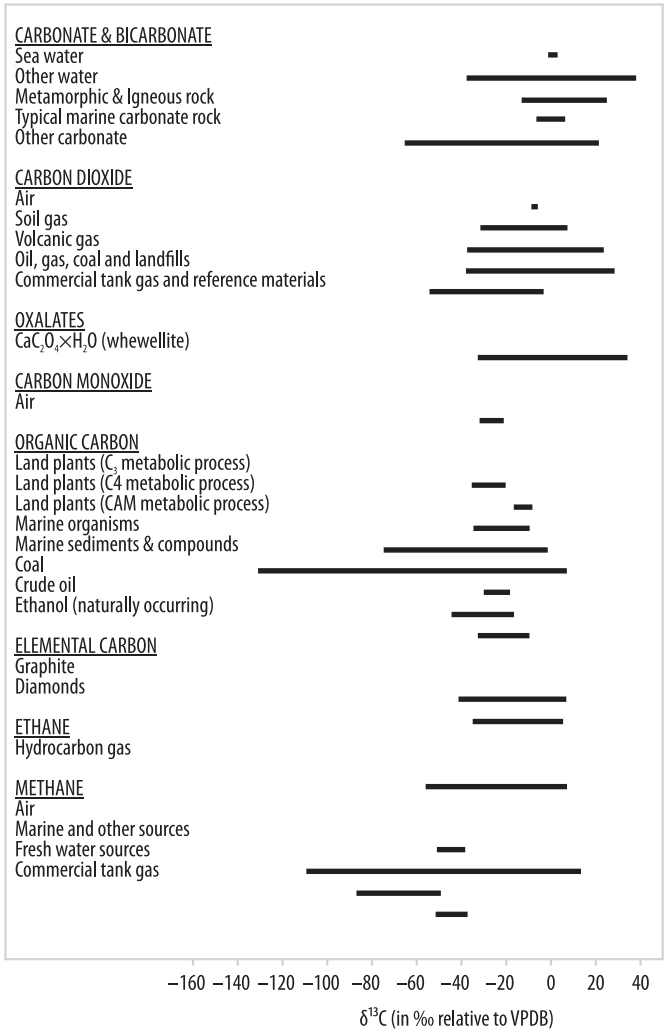

Fig. 2. $\delta^{13}C$ variations in selected carbon-bearing materials. *Source*: redrawn from Meija, J. *et al.* 2016.

carbon isotope measurements in soil science studies have become more and more significant in the past decades, as soil plays an important role in the global carbon cycle.

The significance of stable carbon isotope research in soil science was summarized by Brüggemann, N. *et al.* (2011), who provided a comprehensive overview of the complex network of carbon transformation and transport processes in the plant-soil-atmosphere continuum and demonstrated that research using C isotopes makes it possible to track the fate of C molecules and to integrate information on physical, chemical and biological processes in ecosystems across space and time. Kuzyakov, Y. (2011) stated that isotopic tracers are the most frequently applied and most powerful tracers because of the nearly identical chemical and biochemical properties of isotopes of a single element.

Isotope labelling in soils is based on the fact that biological, chemical and physical

fractionation processes in nature are uniquely $\delta^{13}C$ labelled, and that this labelling is inherited in the soil. This labelling happens naturally. Another technique for understanding C dynamics in soils is to artificially alter the C isotope content of assimilated C using enriched stable (^{13}C) or radioactive (^{14}C) C compounds (CO_2, whole plant residues or plant monomers and polymers) in short pulses (pulse labelling) or over long periods (continuous labelling) (Kuzyakov, Y. 2006).

Stable C isotope fractionation processes in the atmosphere-plant-soil system

The atmospheric CO_2 photosynthesis of plants and the different mechanisms involved were reported by Bender, M.M. (1971), who was the first to describe differences in the $\delta^{13}C$ values of various plant species. Reviews published from the 1980s onwards (e.g. O'Leary, M.H. 1981; Farquhar, G.D. *et al.* 1989; Hayes, J.M. 2001) provided the biochemical background of carbon isotope fractionation during photosynthesis. It was concluded that there are three different mechanisms of photosynthetic CO_2 fixation: the C_3 (Calvin-Benson) pathway, the C_4 (Hatch-Slack) pathway and the crassulacean acid metabolism (CAM). Plant photosynthesis strongly discriminates against the heavier carbon isotope, so the uptake of this isotope by C_3 and C_4 plants averages 19‰ and 4‰ less, respectively, than the atmospheric ambient $\delta^{13}C$ *(Figure 3)* (Boutton, T.W. 1996; Hoefs, J. 2009), which is −8‰ compared to the V-PDB standard (see *Figure 2* and *3*). The CAM pathway is a modification of photosynthetic carbon fixation resulting in $\delta^{13}C$ values ranging from –10 to –28‰ (Boutton, T.W. 1996).

After CO_2 photosynthetic fixation by plants, further fractionation processes take place, resulting in different $\delta^{13}C$ values for different compounds in plants (Park, R. and Epstein, S. 1960). Lignin, lipids and cellulose are depleted, while sugars, amino acids and hemicelluloses are enriched in ^{13}C relative to the bulk plant material (Boutton, T.W. 1996). Therefore, within a single plant $\delta^{13}C$ differences between substances may be as much as 9‰ for C_3 plants and 10.3‰ for C_4 plants (Hobbie, E.A. and Werner, R.A. 2004). Kinetic isotope effects seem to be the cause of these ^{13}C differences (Hoefs, J. 2009).

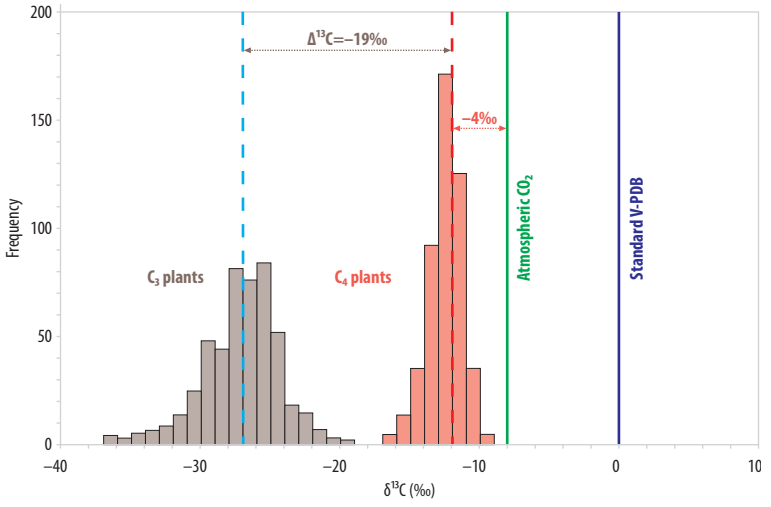

Fig. 3. Isotopic composition of C_3 and C_4 plants compared to atmospheric CO_2 and the C isotope ratio measurement standard. *Source*: redrawn from Ehleringer, J.R. and Cerling, T.E. 2002.

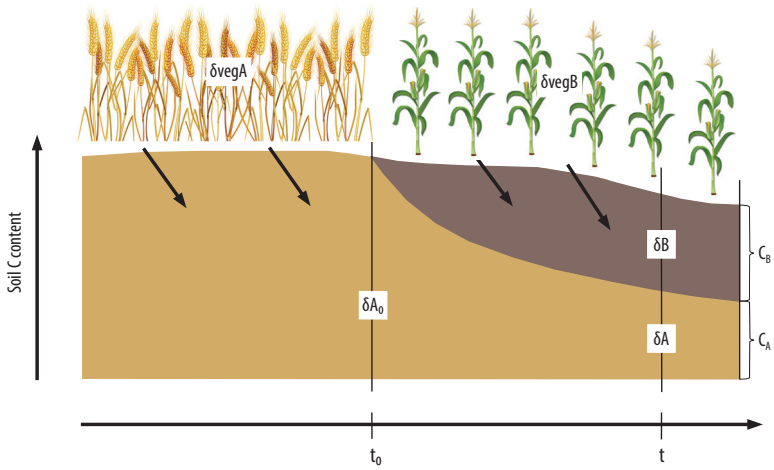

Fig. 4. The basis of C_3–C_4 vegetation change for natural abundance ^{13}C labelling. The figure represents the replacement of SOM derived from previous vegetation A by the new vegetation B. *Source:* redrawn from Balesdent, J. and Mariotti, A. 1996.

In addition, microbes in the soil also discriminate isotopes. The term 'preferential substrate utilization' or 'preferential decomposition' refers to the phenomenon whereby microorganisms select certain individual substances in plant residues and decompose them to CO_2 (Werth, M. and Kuzyakov, Y. 2010). Microbes, especially the bacteria prefer easily decomposable substances (e.g. glucose, sucrose) enriched in ^{13}C rather than lignin and lipids. This preferential substrate utilization is more significant than the ^{13}C-depletion effect of the metabolism (CO_2 from microbial respiration is ^{13}C-depleted compared to the substrate from which it is derived) (Šantrůčková, H. *et al*. 2000). As a consequence, the CO_2 emitted during decomposition is enriched in ^{13}C, while ^{13}C-depleted SOM remains in the soil, as the preferential utilization of the ^{13}C-enriched SOM fractions means that ^{13}C is lost more rapidly than ^{12}C (Ågren, G.I. 1996).

Application of natural C isotope fractionation

The differences in $\delta^{13}C$ values between C_3 and C_4 plants have great importance for soil science since the $\delta^{13}C$ of SOM in the steady-state system is nearly identical to that of the source vegetation from which the organic matter was derived (Boutton, T.W. 1996). This is the basis for numerous stable carbon isotopic applications in soil science.

The natural labelling or $\delta^{13}C$ natural abundance method is based on 1) the above-mentioned physiological difference in the photosynthetic fixation of CO_2 in C_3 and C_4 plants and 2) the assumption that the $\delta^{13}C$ natural abundance signature of SOM is identical to the $\delta^{13}C$ natural abundance signature of the plants from which it is derived, because the isotopic difference between C_3 and C_4 plants is much larger than the isotopic changes occurring during SOM decay (Balesdent, J. and Mariotti, A. 1996). Thus, growing C_4 plants on a C_3 soil or vice versa can be considered as *in situ* labelling. With this method the rate of loss of the C derived from the original vegetation and the incorporation of C derived from the new vegetation can be estimated (Balesdent, J. *et al.* 1987). As a consequence, the natural labelling approach makes it possible 1) to calculate the turnover rate of C derived from the original vegetation (Six, J. and Jastrow, J. 2002) and 2) to separate the different sources of soil CO_2 efflux (Kuzyakov, Y. 2006).

In natural labelling experiments, in contrast to artificial labelling, the isotope differences are smaller, but they have the advantage that no artificially enriched compounds are required. For example, as described by Gunina, A. and Kuzyakov, Y. (2014), the $\delta^{13}C$ natural abundance approach is able to estimate C flows under steady-state conditions without applying artificial tracers. In addition, the distribution of ^{13}C between the pools is more uniform than in artificial pulse labelling methods (Kuzyakov, Y. 2005). One of the strengths of the method is the easy application under field conditions, because there is no need for artificial labelling equipment or isolation from the atmosphere (Kuzyakov, Y. 2006). Therefore, this technique is one of the best for the study of field soil dynamics (Paul, E.A. 2016).

Nevertheless, the method has some shortcomings (Kuzyakov, Y. 2006): (i) C_3 plant/C_4 soil pairs or vice versa are rare under field conditions; (ii) the maximum $\delta^{13}C$ variation of CO_2 between C_3 and C_4 plants is only about 14‰; (iii) there is a ^{13}C discrimination by plants caused by temperature, water availability, air humidity, N supply, light intensity and plant properties (root length, plant sex).

Figure 4 illustrates the basis of the C_3–C_4 vegetation change method representing the two photosynthetic pathways A and B (Balesdent, J. and Mariotti, A. 1996). At the time of the vegetation change (t_0) SOM has an isotopic composition δ_{A0} close to that of the original vegetation.

As this SOM from vegetation A progressively decays, it is partially replaced by SOM derived from the new vegetation B. At a given time *t*, the total SOM content can be expressed as $C = C_A + C_B$ and the isotope composition δ_{AB} of SOM under mixed vegetation is the following:

$$\delta_{AB}\,(C_A + C_B) = \delta_{AB}\,(C) = \delta_A C_A + \delta_B C_B\,, \quad (7)$$

where C_A and C_B stand for the amount of SOM from the old (*A*) and new (*B*) vegetation, respectively, and δ_A and δ_B are the $\delta^{13}C$ values of SOM derived from vegetation A and B, respectively. As $C_A = C - C_B$, Eq. (7) can be rewritten as follows (Amelung, W. *et al.* 2008):

$$\delta_{AB} = \frac{\delta_B C_B}{C} + \frac{\delta_A (C - C_B)}{C} = \frac{\delta_B C_B}{C} + \delta_A \left(1 - \frac{C_B}{C}\right) \quad (8)$$

Hence, the contribution of plant B to the total C content can be calculated as follows (Balesdent, J. and Mariotti, A. 1996; Amelung, W. *et al.* 2008):

$$F = \frac{C_B}{C} = (\delta_{AB} - \delta_A) / (\delta_B - \delta_A) \quad (9)$$

expressed as the fraction of new carbon in the soil (*F*).

Because δ_A and δ_B cannot be measured directly in the mixed cropping system, they must be estimated. The natural labelling method assumes that δ_B is equivalent to the isotopic composition of the new vegetation ($\delta_{VEG\,B}$, see *Figure 4*), and δ_A to the initial $\delta^{13}C$ of the soil or of the control soil remaining under the initial vegetation ($\delta_{REF\,A}$). Hence, the new portions of vegetation B are estimated as follows (Balesdent, J. and Mariotti, A. 1996; Amelung, W. *et al.* 2008):

$$F = (\delta_{AB} - \delta_{REF\,A}) / (\delta_{VEG\,B} - \delta_{REF\,A}) \quad (10)$$

Many studies (Balesdent, J. and Balabane, M. 1992; Six, J. *et al*. 1999; Dignac, M.F. *et al.* 2005; Paul, E.A. *et al*. 2008b; Pausch, J. and Kuzyakov, Y. 2012; Schiedung, H. *et al*. 2017; Poeplau, C. *et al*. 2018) have applied the ^{13}C natural abundance approach to calculate the proportion of C derived from the new vegetation/fresh organic input. Based on Eq. (10), this technique allows also the percentage of C derived from different treatments and amendments to be calculated. For example, Lynch, D.H. *et al*. (2006) estimated the percentage of C derived from different C_4 compost treatments and the retention of compost C in a temperate grassland (C_3) soil in Nova Scotia. Measurements took place one and two years after the application of the compost treatments (corn silage, dairy manure and sewage sludge) and showed that

the fraction of SOM derived from compost was around 33% for most of the treatments. The results indicated that the fraction of compost retained in the soil was the highest for corn silage compost one and two years after the treatment (~ 95% and 90%, respectively).

Another possible application of the ^{13}C natural abundance method is connected with land use change studies (e.g. Yamashita, T. *et al*. 2006; Jakab, G. *et al*. 2018a; Zhang, Q. *et al*. 2018). Agricultural land use disturbs the natural SOM system, e.g. by affecting the aggregate size and stability of SOM (Bilandžija, D. *et al*. 2017; Jakab, G. *et al*. 2018b). With the help of ^{13}C natural abundance these effects can be examined in more detail, as stable carbon isotopes widen the scope of land use research. For instance, the effect of land use changes on the aggregate systems in the soil or how different land use types influence the fraction of C derived from the new vegetation can be examined with the help of ^{13}C natural abundance approach (John, B. *et al*. 2005; Yamashita, T. *et al*. 2006; Paul, S. *et al*. 2008a,b; Liu, Y. *et al*. 2018).

In addition, ^{13}C natural abundance has been successfully applied to trace sediment and SOM transfer during erosion (Papanicolaou, A.N. *et al*. 2003; Alewell, C. *et al*. 2008; Schaub, M. and Alewell, C. 2009; Zollinger, B. *et al*. 2014). The source of eroded soil sediments or suspended organic matter and the rate of soil erosion and redistribution can be monitored by the $\delta^{13}C$ signature of soils. Turnbull, L. *et al*. (2008) used the $\delta^{13}C$ signals of eroded material of soils over a C_4 grass to C_3 shrub transition. They concluded that variations in $\delta^{13}C$ values of SOM in bulk eroded sediment can be used to trace changes in erosion dynamics over events of different magnitudes and over different vegetation types. Jacinthe, P.A. *et al*. (2009) determined the amount and source of eroded soil organic carbon retained in C_3 grass filters receiving runoff from areas supporting C_4 vegetation. Novara, A. *et al*. (2015) measured the $\delta^{13}C$ values of different soil profiles sampled along a Sicilian vineyard slope and quantified the rates of erosion.

Estimation of the turnover rate of C pools

The carbon turnover rate is the rate of C cycling from one pool to another. If the system is in the steady-state condition (i.e. input into the pool is equal to the output), the value of the turnover rate is the ratio of the input amount per time unit to the total pool amount. In this case, the mean residence time (i.e. the mean period of residence of C in the given pool) is the inverse of the turnover rate (Kuzyakov, Y. 2006).

Based on the simplest assumption, SOM consists of a homogeneous, single C pool, which decomposes exponentially following first-order kinetics (Stanford, G. and Smith, S.J. 1972). For the amounts of SOM from the old vegetation:

$$C_A = (C_A + C_B) \exp(-kt), \qquad (11)$$

where C_A and C_B stand for the amount of SOM from the old (A) and new (B) vegetation, k is the decay rate constant and t is the time since vegetation change. The mean residence time (*MRT*) can be calculated as the inverse of the decay rate constant as follows (Amelung, W. *et al*. 2008):

$$MRT = \frac{1}{k} = -t/\ln(1 - F) \qquad (12)$$

SOM pools dominated by turnover times ranging from a year to several hundreds of years have been calculated with the help of the natural labelling approach (Balesdent, J. and Mariotti, A. 1996).

Carbon turnover time is not just an important indicator of SOM dynamics, but is a key parameter in coupled climate-carbon cycle models (e.g. Earth System Models). Hence, there is an urgent need to accurately estimate the turnover times of SOM to predict the future sizes of the terrestrial C sinks and sources and to obtain a better understanding of climate-carbon feedback (Carvalhais, N. *et al*. 2014; He, Y. *et al*. 2016; Wang, J. *et al*. 2018).

Balesdent, J. *et al*. (1987) were the first to use the natural ^{13}C abundance method on two French sites which originally had C_3 type veg-

etation. They cultivated maize (C_4 type vegetation) to achieve a C_3/C_4 vegetation change. An organic carbon turnover rate of 22% was calculated from the $\delta^{13}C$ values of soils sampled at one experimental site after 13 years of maize cultivation, with different annual rates. This suggested that the decay of SOM cannot be described using a single carbon pool model. A turnover time of 36 years was calculated for this site assuming an exponential decay. At another experimental site, where continuous maize cultivation for 23 years was applied after pine forest clearing, two treatments were used: in the first, leaves and stalks were incorporated back into the soil, while in the second, leaves and stalks were removed for the last 17 years. The percentage of organic carbon derived from maize was calculated for different particle size fractions in the topsoil (0–30 cm) and subsoil (30–40 cm) horizons. The turnover of the coarse sand fraction (200–2,000 mm) was found to be the most rapid, while the fine clay fraction (<0.2 mm) contained most of the SOM.

Since then, a number of studies have used the ^{13}C natural abundance method for SOM turnover rate calculations for different purposes, but the work of Balesdent, J. *et al.* (1987) forecast the major questions of SOM research which have since been studied with this method. These are the 1) estimation of the turnover time of different physically and/or chemically separated SOM fractions representing distinct SOM fractions connected to different soil textures or minerals (Martin, A. *et al*. 1990; Bonde, T.A. *et al*. 1992; Balesdent, J. *et al*. 1998; Shang, C. and Tiessen, H. 2000; Liao, J.D. *et al*. 2006; Dalal, R.C. *et al*. 2013); 2) estimation of the turnover time of different SOM pools (Bernoux, M. *et al.* 1998; Derrien, D. and Amelung, W. 2011); 3) estimation of the turnover time of SOM derived from different treatments or land uses (Six, J. and Jastrow, J. 2002; Zach, A. *et al*. 2006; Novara, A. *et al*. 2013); 4) comparison of the turnover time of SOM at different soil depths (Bernoux, M. *et al*. 1998; Flessa, H. *et al*. 2017).

A combination of these topics is embedded in many other studies. For example, Collins, H.P. *et al.* (1999) investigated the soil C dynamics in the Corn Belt region of the central USA. They calculated the per cent of C derived from corn after conversion to a monoculture of C_4 corn and the MRTs of the C_3 soils. The proportion of corn-derived C decreased with soil depth and was minimal in the 50–100 cm depth increments of fine-textured soils. The mean residence time of non-corn C (C_3) ranged from 36 to 108 years at the surface and up to 769 years at the subsoil depth. It was shown that clay minerals effectively protected the organic matter in the case of older C_3-derived C (longer MRTs), while no such protection was observed for the younger C_4-derived C (shorter MRTs).

John, B. *et al*. (2005) estimated the turnover times of different density fractions of SOM (free particulate organic matter with a density <1.6 g cm^{-3}, light occluded particulate organic matter with a density of <1.6 g cm^{-3}, dense occluded particulate organic matter with a density of 1.6–2.0 g cm^{-3} and mineral-associated SOM with a density >2 g cm^{-3}) and of SOM from different depths. They calculated turnover times of 54, 144 and 223 years for the 0–30 cm, 30–45 cm and 45–60 cm horizons, respectively. The mean turnover times for the density fractions were found to be the following: 22 years for the free particulate organic matter, 49 years for the dense occluded particulate organic matter, 63 years for mineral-associated SOM and 83 years for light occluded particulate organic matter.

Lisboa, C.C. *et al*. (2009) calculated the turnover time of different SOM fractions (>250 mm, 53–250 mm, 2–53 mm, <2 mm) applying a two-pool (active and slow decomposition rate) exponential model for a forest-to-pasture chrono-sequence in the Brazilian Amazon. Except for the >250 mm fraction no difference was detected between the fractions in the active pool phase, whereas in the slow pool phase the fractions were separated according to their turnover rates: the clay-associated SOM (fraction <2 mm) had the greatest turnover rate (>2,500 years), the microaggregate and silt-associated SOM had medium turnover rates (498 and 210 years,

respectively) and the particulate organic matter (>250 mm fraction) had the smallest turnover rate (~ 1 year).

Panettieri, M. *et al*. (2017) studied the different turnover times of fractionated water-stable aggregates (larger macro-aggregates with 2.0–7.1 mm, macro-aggregates with 0.200–2.00 mm, microaggregates with 0.050–0.200 mm and silt + clay fraction with <0.050 mm) of permanent cropland and temporary grassland plots after nine and three years of maize cultivation, respectively. The calculated turnover times for the two land uses were similar for the micro- and macro-aggregates but different for the silt + clay fraction. Namely, the MRT of the silt + clay fraction of grassland soil was twice as of the cropland soil confirming that this smallest fraction is affected to the greatest extent by land use practices, and particularly tillage. It could be explained by the increased degradation of SOM due to higher aeration caused by tillage.

Soil CO_2 efflux source determination

Besides the estimation of SOM turnover time, the ^{13}C natural abundance method is well applicable to partition the CO_2 fluxes from the soil (Cheng, W. 1996). The evaluation of the contribution made by different C sources to soil CO_2 efflux is also a key parameter in determining whether the soil is a net source or sink of atmospheric CO_2 (Kuzyakov, Y. and Larionova, A.A. 2005).

According to Kuzyakov, Y. (2006) there are five main sources of soil CO_2 efflux *(Figure 5)*: 1) microbial decomposition of SOM (termed basal respiration), 2) microbial decomposition of SOM affected by recent input of rhizodeposits and/or fresh undecomposed plant residues (termed priming effect), 3) microbial decomposition of partly decomposed dead plant remains, 4) microbial decomposition of rhizo-deposits of living roots (termed rhizomicrobial respiration) and 5) root respiration (respiration of assimilates by roots of autotrophic plants). These CO_2 effluxes represent different C pools with different turnover rates and MRTs (see *Figure 5*).

The pedogenic or anthropogenic acidification of soils containing $CaCO_3$ is also a source of CO_2 efflux in the soil, but its contribution is only significant on the geological time scale and not on the sub-annual to decadal time scales used in soil research studies (Kuzyakov, Y. 2006).

With the help of the ^{13}C natural labelling approach, it is possible to separate the sources of soil respiration. Growing C_4 plants on a C_3 soil or vice versa and tracing the $\delta^{13}C$ value of CO_2 efflux from the soil allows the separation of SOM-derived from plant-derived CO_2 (see *Figure 5*). If additional data on the $\delta^{13}C$ values of microbial biomass and roots is available, root and rhizomicrobial respiration can also be partitionated, as can the separation of SOM-derived basal respiration from the microbial decomposition of plant residues.

Natural C_3/C_4 vegetation differences are also used to partition the autotrophic (root respiration) and heterotrophic (other 5 respiration sources in *Figure 5*) soil respiration in many studies (e.g. Rochette, P. and Flanagan, L.B. 1997; Giardina, C.P. *et al.* 2004; Millard, P. *et al.* 2008).

Millard, P. *et al.* (2010) were the first to quantify the proportion of SOM-derived CO_2 in a forest soil using ^{13}C natural abundance discrimination, with carbon input derived solely from C_3 photosynthesis. For this, measured $\delta^{13}C$ values of root respiration (−27.60 ± 0.51‰) and SOM-derived respiration (−25.10 ± 0.88‰) were used as the end points of a two-component mixing model using the small isotopic difference between them. The calculated mean percentage of SOM-derived CO_2 was 0.61 ± 0.28.

By adding C_4 plant residues to a C_3 soil or vice versa and measuring their contribution to the total CO_2 efflux it is also possible to separate the CO_2 originating from plant residues and that derived from the microbial decomposition of SOM. In addition, by comparing soil with added residues to control soil with no residue addition, the priming effect can be calculated using the ^{13}C natural labelling approach (Kuzyakov, Y. 2006). For

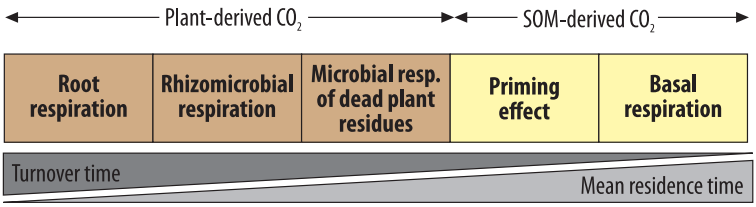

Fig. 5. Main sources of soil CO_2 efflux and C pools in order of turnover rates and residence times. *Source*: redrawn from Kuzyakov, Y. and Gavrichkova, O. 2010.

example, Kuzyakov, Y. and Cheng, W. (2001) applied the ^{13}C natural abundance method to partition the soil-derived and root-derived (root respiration plus rhizomicrobial respiration) CO_2 from C_4 prairie soil planted with C_3 wheat in a 7-day laboratory experiment. Photosynthesis was greatly reduced and, on average, 75% of total CO_2 efflux from the soil proved to be root-derived and 25% soil-derived. When the priming effect was compared for planted and non-planted soils a positive priming effect (42 mg C kg^{-1} h^{-1} and 33 kg C ha^{-1} d^{-1}) was recorded during the first 3 days, whereas without light, the priming effect decreased and was negative due to the reduction of exudation.

Werth, M. and Kuzyakov, Y. (2009) used the natural ^{13}C labelling approach to partition root respiration, rhizomicrobial respiration and basal respiration under field conditions in a loamy Haplic Luvisol in Stuttgart, Germany. They used the $\delta^{13}C$ values of SOM, roots, microbial biomass and total CO_2 efflux from the soil and applied isotopic mass balance equations to calculate the contributions of the three sources of CO_2 efflux. The $\delta^{13}C$ values from a bare-fallow plot were used to calculate the ^{13}C fractionation between SOM and CO_2 and between microbial biomass and CO_2 and the contribution of different CO_2 sources was estimated, taking into account the ^{13}C fractionation.

The calculations revealed significant changes between the results with and without ^{13}C fractionation. It was therefore suggested that the isotope fractionation processes of ^{13}C should be embedded in studies dealing with CO_2 efflux partitioning. Werth, M. and Kuzyakov, Y. (2010) reviewed the possible uncertainties connected with ^{13}C fractionation in the ^{13}C natural abundance method, with special attention to the partitioning of CO_2 efflux. It was concluded that even a small variation (±1.0‰) in the $\delta^{13}C$ value of the 'endmembers' of the mixing equations led to strong uncertainties. In addition, if significant isotope fractionation takes place, the uncertainties increase significantly. As possible solutions, they recommended various approaches to reduce uncertainties: 1) to increase the difference in $\delta^{13}C$ value between the two 'endmembers' (if necessary, using artificial labelling); 2) to estimate the fractionation of individual processes in the specific study, not using mean values estimated in other studies; 3) to analyse the $\delta^{13}C$ values of individual substance groups or substances (i.e. compound-specific isotope analysis).

Conclusions

The ^{13}C natural abundance approach occupies an important place among the isotope applications used in soil research, especially for the calculation of SOM turnover and the partitioning of CO_2 efflux sources.

The ^{13}C natural abundance approach combined with other methods is a useful tool to measure the effect of different human-induced changes on organic carbon storage, such as land use change, erosion and soil management. Along with the traditional methods of watershed monitoring, slope

measurements and rainfall simulation experiments or tracer applications (rare earth elements or radionuclides), stable carbon isotope measurements provide additional spatial information on soil erosion dynamics. In addition, the ^{13}C natural abundance approach in combination with photogrammetry or remote sensing could be useful to precisely monitor areas affected by different land use changes.

With the combination of ^{13}C natural abundance method and ^{14}C labelling, the contribution of carbon sources to the carbon pools can be distinguished in more detail and the priming effect connected to the processes can be calculated. The measurement of the natural ^{14}C abundance of SOM extends the timescales for C cycling to millennia supplementing the turnover times ranging from a year to several hundreds of years calculated by the ^{13}C natural labelling approach. The physical fractionation of soils combined with isotope labelling provides another possibility to estimate the turnover times of physically defined SOM pools.

Data obtained using the ^{13}C natural abundance technique provide important information on SOM dynamics, which has been in the focus of interest in recent years due to the significant role of soil in the global carbon cycle. The determination of the turnover time and size of the active and passive soil reservoirs is essential for the evaluation of whether they serve as potential sources or sinks for atmospheric CO_2. Therefore, techniques such as the ^{13}C natural abundance approach, not only lead to a better understanding of processes in the global carbon cycle but also provide fundamental information for climate change mitigation.

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REFERENCES

Ågren, G.I., Bosatta, E. and Balesdent, J. 1996. Isotope discrimination during decomposition of organic matter: A theoretical analysis. *Soil Science Society of America Journal* 60. (4): 1121–1126.

Alewell, C., Birkholz, A., Meusburger, K., Schindler Wildhaber, Y. and Mabit, L. 2016. Quantitative sediment source attribution with compound-specific isotope analysis in a C_3 plant-dominated catchment (central Switzerland). *Biogeosciences* 13. (5): 1587–1596.

Alewell, C., Meusburger, K., Brodbeck, M. and Bänninger, D. 2008. Methods to describe and predict soil erosion in mountain regions. *Landscape and Urban Planning* 88. (2–4): 46–53.

Allègre, C.J. 2008. *Isotope Geology*. New York, Cambridge University Press.

Amelung, W., Brodowski, S., Sandhage-Hofmann, A. and Bol, R. 2008. Combining biomarker with stable isotope analyses for assessing the transformation and turnover of soil organic matter. *Advances in Agronomy* 100. (6): 155–250.

Balesdent, J. and Balabane, M. 1992. Maize root-derived soil organic carbon estimated by natural ^{13}C abundance. *Soil Biology and Biochemistry* 24. (2): 97–101.

Balesdent, J. and Mariotti, A. 1996. Measurement of soil organic matter turnover using ^{13}C natural abundance. In *Mass Spectrometry of Soils*. Eds.: Boutton, T.W. and Yamasaki, S.I., New York, Marcel Dekker, 83–111.

Balesdent, J., Besnard, E., Arrouays, D. and Chenu, C. 1998. The dynamics of carbon in particle-size fractions of soil in a forest-cultivation sequence. *Plant and Soil* 201. (1): 49–57.

Balesdent, J., Mariotti, A. and Guillet, B. 1987. Natural ^{13}C abundance as a tracer for studies of soil organic matter dynamics. *Soil Biology and Biochemistry* 19. (1): 25–30.

Barta, G., Bradák, B., Novothny, Á., Markó, A., Szeberényi, J., Kiss, K. and Kovács, J. 2018. The influence of paleogeomorphology on the stable isotope signals of paleosols. *Geoderma* 330. 221–231.

Bender, M.M. 1971. Variations in the $^{13}C/^{12}C$ ratios of plants in relation to the pathway of photosynthetic carbon dioxide fixation. *Phytochemistry* 10. (6): 1239–1244.

Bernoux, M., Cerri, C.C., Neill, C. and De Moraes, J.F.L. 1998. The use of stable carbon isotopes for estimating soil organic matter turnover rates. *Geoderma* 82. (1–3): 43–58.

Bigeleisen, J. 1965. Chemistry of Isotopes. *Science* 147. (3657): 463–471.

Bigeleisen, J. and Wolfsberg, M. 1958. Theoretical and experimental aspects of isotope effects in chemical kinetics. In *Advances in Chemical Physics*.

Eds.: Prigogine, I. and Debye, P., New York, John Wiley and Sons, 15–76.

Bilandžija, D., Zgorelec, Ž. and Kisić, I. 2017. Influence of tillage systems on short-term soil CO_2 emissions. *Hungarian Geographical Bulletin* 66. (1): 29–35.

Bonde, T.A., Christensen, B.T. and Cerri, C.C. 1992. Dynamics of soil organic matter as reflected by natural ^{13}C abundance in particle size fractions of forested and cultivated oxisols. *Soil Biology and Biochemistry* 24. (3): 275–277.

Boutton, T.W. 1996. Stable carbon isotope ratios of soil organic matter and their use as indicators of vegetation and climate change. In *Mass Spectrometry of Soils.* Eds.: Boutton, T.W. and Yamasaki, S.I., New York, Marcel Dekker, 47–82.

Brandt, C., Cadisch, G., Nguyen, L.T., Vien, T.D. and Rasche, F. 2016. Compound-specific $\delta^{13}C$ isotopes and Bayesian inference for erosion estimates under different land use in Vietnam. *Geoderma Regional* 7. (3): 311–322.

Brandt, C., Dercon, G., Cadisch, G., Nguyen, L.T., Schuller, P., Linares, C.B., Santana, A.C., Golosov, V., Benmansour, M., Amenzou, N., Xinbao, Z. and Rasche, F. 2018. Towards global applicability? Erosion source discrimination across catchments using compound-specific $\delta^{13}C$ isotopes. *Agriculture, Ecosystems and Environment* 256. (A1–A2): 114–122.

Brüggemann, N., Gessler, A., Kayler, Z., Keel, S.G., Badeck, F., Barthel, M., Boeckx, P., Buchmann, N., Brugnoli, E., Esperschütz, J., Gavrichkova, O., Ghashghaie, J., Gomez-Casanovas, N., Keitel, C., Knohl, A., Kuptz, D., Palacio, S., Salmon, Y., Uchida, Y. and Bahn, M. 2011. Carbon allocation and carbon isotope fluxes in the plant-soil-atmosphere continuum: A review. *Biogeosciences* 8. (11): 3457–3489.

Carvalhais, N., Forkel, M., Khomik, M., Bellarby, J., Jung, M., Migliavacca, M., Mu, M., Saatchi, S., Santoro, M., Thurner, M., Weber, U., Ahrens, B., Beer, C., Cescatti, A., Randerson, J.T. and Reichstein, M. 2014. Global covariation of carbon turnover times with climate in terrestrial ecosystems. *Nature* 514. (7521): 213–217.

Cerling, T.E., Quade, J., Wang, Y. and Bowman, J.R. 1989. Carbon isotopes in soils and palaeosols as ecology and palaeoecology indicators. *Nature* 341. (6238): 138–139.

Cheng, W. 1996. Measurement of rhizosphere respiration and organic matter decomposition using natural ^{13}C. *Plant and Soil* 183. (2): 263–268.

Clayton, R.N., Grossman, L. and Mayeda, T.K. 1973. A component of primitive nuclear composition in carbonaceous meteorites. *Science* 182. (4111): 485–488.

Collins, H.P., Christenson, D.R., Blevins, R.L., Bundy, L.G., Dick, W.A., Huggins, D.R. and Paul, E.A. 1999. Soil carbon dynamics in corn-based agroecosystems: results from carbon-13 natural abundance. *Soil Science Society of America Journal* 63. (3): 584–591.

Craig, H. 1953. The geochemistry of the stable carbon isotopes. *Geochimica et Cosmochimica Acta* 3. (2–3): 53–92.

Dalal, R.C., Thornton, C.M. and Cowie, B.A. 2013. Turnover of organic carbon and nitrogen in soil assessed from $\delta^{13}C$ and $\delta^{15}N$ changes under pasture and cropping practices and estimates of greenhouse gas emissions. *Science of the Total Environment* 465. 26–35.

Dansgaard, W. 1964. Stable isotopes in precipitation. *Tellus* 16. (4): 436–468.

Dawson, T.E. and Siegwolf, R.T.W. 2007. Using stable isotopes as indicators, tracers, and recorders of ecological change: some context and background. *Terrestrial Ecology* 1. 1–18.

Dawson, T.E., Mambelli, S., Plamboeck, A.H., Templer, P.H. and Tu, K.P. 2002. Stable isotopes in plant ecology. *Annual Review of Ecology and Systematics* 33. (1): 507–559.

Deméný, A. 2004. Stabilizotóp-geokémia (Stable isotope geochemistry). *Magyar Kémiai Folyóirat* 109–110. (4): 192–198.

Derrien, D. and Amelung, W. 2011. Computing the mean residence time of soil carbon fractions using stable isotopes: Impacts of the model framework. *European Journal of Soil Science* 62. (2): 237–252.

Dignac, M.F., Bahri, H., Rumpel, C., Rasse, D.P., Bardoux, G., Balesdent, J., Girardin, C., Chenu, C. and Mariotti, A. 2005. Carbon-13 natural abundance as a tool to study the dynamics of lignin monomers in soil: An appraisal at the Closeaux experimental field (France). *Geoderma* 128. (1–2): 3–17.

Ehleringer, J.R. and Cerling, T.E. 2002. C_3 and C_4 Photosynthesis. In *Encyclopedia of Global Environmental Change, Vol. 2. The Earth system: biological and ecological dimensions of global environmental change*. Eds.: Mooney, H.A. and Canadell, J.G., Chichester, John Wiley and Sons, 186–190.

Ehleringer, J.R. and Rundel, P.W. 1989. Stable Isotopes: History, Units, and Instrumentation. In *Stable Isotopes in Ecological Research. Ecological Studies (Analysis and Synthesis).* Vol. 68. Eds.: Rundel, P.W., Ehleringer, J.R. and Nagy, K.A., New York, Springer, 1–15.

Epstein, S., Buchsbaum, R., Lowenstam, H.A. and Urey, H.C. 1953. Revised carbonate-water isotopic temperature scale. *Geological Society of America Bulletin* 64. (11): 1315–1326.

Farquhar, G.D., Ehleringer, J.R. and Hubick, K.T. 1989. Carbon isotope discrimination and photosynthesis. *Annual Review of Plant Physiology and Plant Molecular Biology* 40. (1): 503–537.

Flessa, H., Ludwig, B., Heil, B. and Merbach, W. 2000. The origin of soil organic C, dissolved organic C and respiration in a long-term maize experiment in Halle, Germany, determined by ^{13}C natural abundance. *Journal of Plant Nutrition and Soil Science* 163. (2): 157–163.

Fox, D.L. and Koch, P.L. 2004. Carbon and oxygen isotopic variability in Neogene paleosol carbonates: constraints on the evolution of the C_4-grasslands of the Great Plains, USA. *Palaeogeography, Palaeoclimatology, Palaeoecology* 207. (3–4): 305–329.

Giardina, C.P., Binkley, D., Ryan, M.G., Fownes, J.H. and Senock, R.S. 2004. Belowground carbon cycling in a humid tropical forest decreases with fertilization. *Oecologia* 139. (4): 545–550.

Gunina, A. and Kuzyakov, Y. 2014. Pathways of litter C by formation of aggregates and SOM density fractions: Implications from ^{13}C natural abundance. *Soil Biology and Biochemistry* 71. 95–104.

Häring, V., Fischer, H., Cadisch, G. and Stahr, K. 2013. Implication of erosion on the assessment of decomposition and humification of soil organic carbon after land use change in tropical agricultural systems. *Soil Biology and Biochemistry* 65. 158–167.

Hayes, J.M. 2001. Fractionation of carbon and hydrogen isotopes in biosynthetic processes. *Reviews in Mineralogy and Geochemistry* 43. (1): 225–277.

He, Y., Trumbore, S.E., Torn, M.S., Harden, J.W., Vaughn, L.J.S., Allison, S.D. and Randerson, J.T. 2016. Radiocarbon constraints imply reduced carbon uptake by soils during the 21st century. *Science* 353. (6306): 1419–1424.

Hobbie, E.A. and Werner, R.A. 2004. Intramolecular, compound-specific, and bulk carbon isotope patterns in C_3 and C_4 plants: a review and synthesis. *New Phytologist* 161. (2): 371–385.

Hoefs, J. 2009. *Stable Isotope Geochemistry*. Berlin Heidelberg, Springer-Verlag.

Jacinthe, P.A., Lal, R. and Owens, L.B. 2009. Application of stable isotope analysis to quantify the retentsion of erosded carbin in grass filters at the North Appalachian experimental watersheds. *Geoderma* 148. (3–4): 405–412.

Jakab, G., Hegyi, I., Fullen, M., Szabó, J., Zacháry, D. and Szalai, Z. 2018a. A 300-year record of sedimentation in a small tilled catena in Hungary based on $\delta^{13}C$, $\delta^{15}N$, and C/N distribution. *Journal of Soils and Sediments* 18. (4): 1767–1779.

Jakab, G., Rieder, Á., Vancsik, A.V. and Szalai, Z. 2018b. Soil organic matter characterisation by photometric indices or photon correlation spectroscopy: Are they comparable? *Hungarian Geographical Bulletin* 67. (2): 1–12.

John, B., Yamashita, T., Ludwig, B. and Flessa, H. 2005. Storage of organic carbon in aggregate and density fractions of silty soils under different types of land use. *Geoderma* 128. (1–2): 63–79.

Kuzyakov, Y. 2005. Theoretical background for partitioning of root and rhizomicrobial respiration by $\delta^{13}C$ of microbial biomass. *European Journal of Soil Biology* 41. (1–2): 1–9.

Kuzyakov, Y. 2006. Sources of CO_2 efflux from soil and review of partitioning methods. *Soil Biology and Biochemistry* 38. (3): 425–448.

Kuzyakov, Y. 2011. How to link soil C pools with CO_2 fluxes? *Biogeosciences* 8. (6): 1523–1537.

Kuzyakov, Y. and Cheng, W. 2001. Photosynthesis controls of rhizosphere respiration and organic matter decomposition. *Soil Biology and Biochemistry* 33. (14): 1915–1925.

Kuzyakov, Y. and Gavrichkova, O. 2010. Review: Time lag between photosynthesis and carbon dioxide efflux from soil: A review of mechanisms and controls. *Global Change Biology* 16. (12): 3386–3406.

Kuzyakov, Y. and Larionova, A.A. 2005. Root and rhizomicrobial respiration: A review of approaches to estimate respiration by autotrophic and heterotrophic organisms in soil. *Journal of Plant Nutrition and Soil Science* 168. (4): 503–520.

Liao, J.D., Boutton, T.W. and Jastrow, J.D. 2006. Organic matter turnover in soil physical fractions following woody plant invasion of grassland: Evidence from natural ^{13}C and ^{15}N. *Soil Biology and Biochemistry* 38. (11): 3197–3210.

Lisboa, C.C., Conant, R.T., Haddix, M.L., Cerri, C.E.P. and Cerri, C.C. 2009. Soil carbon turnover measurement by physical fractionation at a forest-to-pasture chronosequence in the Brazilian Amazon. *Ecosystems* 12. (7): 1212–1221.

Liu, Y., Liu, W., Wu, L., Liu, C., Wang, L., Chen, F. and Li, Z. 2018. Soil aggregate-associated organic carbon dynamics subjected to different types of land use: Evidence from ^{13}C natural abundance. *Ecological Engineering* 122. 295–302.

Lynch, D.H., Voroney, R.P. and Warman, P.R. 2006. Use of ^{13}C and ^{15}N natural abundance techniques to characterize carbon and nitrogen dynamics in composting and in compost-amended soils. *Soil Biology and Biochemistry* 38. (1): 103–114.

Martin, A., Mariotti, A., Balesdent, J., Lavelle, P. and Vuattoux, R. 1990. Estimate of organic matter turnover rate in a savanna soil by ^{13}C natural abundance measurements. *Soil Biology and Biochemistry* 22. (4): 517–523.

Mauersberger, K., Erbacher, B., Krankowsky, D., Guenther, J. and Nickel, R. 1999. Ozone isotope enrichment: isotopomer-specific rate coefficients. *Science* 283. (5400): 370–372.

Meija, J., Coplen, T.B., Berglund, M., Brand, W.A., De Bièvre, P., Gröning, M., Holden, N.E., Irrgeher, J., Loss, R.D., Walczyk, T. and Prohaska, T. 2016. Atomic weights of the elements 2013 (IUPAC Technical Report). *Pure Appl. Chem* 88. (3): 265–291.

Michener, R.H. and Lajtha, K. 2007. *Stable isotopes in ecology and environmental science*. Malden, Blackwell Publishing.

Millard, P., Midwood, A.J., Hunt, J.E., Barbour, M.M. and Whitehead, D. 2010. Quantifying the contribution of soil organic matter turnover to forest soil respiration, using natural abundance $\delta^{13}C$. *Soil Biology and Biochemistry* 42. (6): 935–943.

Millard, P., Midwood, A.J., Hunt, J.E., Whitehead, D. and Boutton, T.W. 2008. Partitioning soil surface CO_2 efflux into autotrophic and heterotrophic components, using natural gradients in soil $\delta^{13}C$ in an undisturbed savannah soil. *Soil Biology and Biochemistry* 40. (7): 1575–1582.

Mook, W.G. 2001. Environmental isotopes in the hydrological cycle – Principles and applications, Introduction, theory, methods, review. In *IHP-V Technical Documents in Hydrology.* International Atomic Energy Agency and United Nations Educational, Scientific and Cultural Organization. 39. (1): 1–164.

Nier, A.O. and Gulbransen, E.A. 1939. Variations in the relative abundance of the carbon isotopes. *Journal of the American Chemical Society* 61. (3): 697–698.

Norman, A.G. and Werkman, C.H. 1943. The use of the nitrogen isotope N^{15} in determining nitrogen recovery from plant materials decomposing in soil. *Agronomy Journal* 35. (12): 1023–1025.

Novara, A., Cerdà, A., Dazzi, C., Lo Papa, G., Santoro, A. and Gristina, L. 2015. Effectiveness of carbon isotopic signature for estimating soil erosion and deposition rates in Sicilian vineyards. *Soil & Tillage Research* 152. 1–7.

Novara, A., Gristina, L., Kuzyakov, Y., Schillaci, C., Laudicina, V.A. and La Mantia, T. 2013. Turnover and availability of soil organic carbon under different Mediterranean land-uses as estimated by ^{13}C natural abundance. *European Journal of Soil Science* 64. (4): 466–475.

O'Leary, M.H. 1981. Carbon isotope fractionation in plants. *Phytochemistry* 20. (4): 553–567.

Ohkouchi, N., Ogawa, N.O., Chikaraishi, Y., Tanaka, H. and Wada, E. 2015. Biochemical and physiological bases for the use of carbon and nitrogen isotopes in environmental and ecological studies. *Progress in Earth and Planetary Science* 2. (1): 1–17.

Pálfy, J., Demény, A., Haas, J., Hetényi, M., Orchard, M.J. and Veto, I. 2001. Carbon isotope anomaly and other geochemical changes at the Triassic-Jurassic boundary from a marine section in Hungary. *Geology* 29. (11): 1047–1050.

Panettieri, M., Rumpel, C., Dignac, M.F. and Chabbi, A. 2017. Does grassland introduction into cropping cycles affect carbon dynamics through changes of allocation of soil organic matter within aggregate fractions? *Science of the Total Environment* 576. 251–263.

Papanicolaou, A.N., Fox, J.F. and Marshall, J. 2003. Soil fingerprinting in the Palouse Basin: USA using stable carbon and nitrogen isotopes. *International Journal of Sediment Research* 18. (2): 278–284.

Park, R. and Epstein, S. 1960. Carbon isotope fractionation during photosynthesis. *Geochimica et Cosmochimica Acta* 21. (1–2): 110–126.

Paul, E.A. 2016. The nature and dynamics of soil organic matter: Plant inputs, microbial transformations, and organic matter stabilization. *Soil Biology and Biochemistry* 98. 109–126.

Paul, S., Flessa, H., Veldkamp, E. and López-Ulloa, M. 2008a. Stabilization of recent soil carbon in the humid tropics following land use changes: evidence from aggregate fractionation and stable isotope analyses. *Biogeochemistry* 87. (3): 247–263.

Paul, S., Veldkamp, E. and Flessa, H. 2008b. Soil organic carbon in density fractions of tropical soils under forest – pasture – secondary forest land use changes. *European Journal of Soil Science* 59. (2): 359–371.

Pausch, J. and Kuzyakov, Y. 2012. Soil organic carbon decomposition from recently added and older sources estimated by $\delta^{13}C$ values of CO_2 and organic matter. *Soil Biology and Biochemistry* 55. 40–47.

Poeplau, C., Don, A., Six, J., Kaiser, M., Benbi, D., Chenu, C., Cotrufo, M.F., Derrien, D., Gioacchini, P., Grand, S., Gregorich, E., Griepentrog, M., Gunina, A., Haddix, M., Kuzyakov, Y., Kühnel, A., Macdonald, L.M., Soong, J., Trigalet, S., Vermeire, M.L., Rovira, P., van Wesemael, B., Wiesmeier, M., Yeasmin, S., Yevdokimov, I. and Nieder, R. 2018. Isolating organic carbon fractions with varying turnover rates in temperate agricultural soils – A comprehensive method comparison. *Soil Biology and Biochemistry* 125. 10–26.

Rochette, P. and Flanagan, L.B. 1997. Quantifying rhizosphere respiration in a corn crop under field conditions. *Soil Science Society of America Journal* 61. (2): 466–474.

Šantrůčková, H., Bird, M.I., Frouz, J., Šustr, V. and Tajovský, K. 2000. Natural abundance of ^{13}C in leaf litter as related to feeding activity of soil invertebrates and microbial mineralisation. *Soil Biology and Biochemistry* 32. (11–12): 1793–1797.

Schaub, M. and Alewell, C. 2009. Stable carbon isotopes as an indicator for soil degradation in an alpine environment Urseren Valley, Switzerland. *Rapid Communications in Mass Spectrometry* 23. (10): 1499–1507.

Schiedung, H., Tilly, N., Hütt, C., Welp, G., Brüggemann, N. and Amelung, W. 2017. Spatial controls of topsoil and subsoil organic carbon turnover under C_3–C_4 vegetation change. *Geoderma* 303. 44–51.

Schwartz, D., Mariotti, A., Lanfranchi, R. and Guillet, B. 1986. $^{13}C/^{12}C$ ratios of soil organic matter as indicators of vegetation changes in the Congo. *Geoderma* 39. (2): 97–103.

Shang, C. and Tiessen, H. 2000. Carbon turnover and carbon-13 natural abundance in organo-mineral fractions of a tropical dry forest soil under cultivation. *Soil Science Society of America Journal* 64. (6): 2149–2155.

Six, J. and Jastrow, J. 2002. Organic matter turnover. In *Encyclopedia of Soil Science*. Ed.: Lal, R., New York, Marcel Dekker, 936–942.

Six, J., Elliott, E.T. and Paustian, K. 1999. Aggregate and soil organic matter dynamics under conventional and no-tillage systems. *Soil Science* 63. 1350–1358.

Stanford, G. and Smith, S.J. 1972. Nitrogen mineralization potentials of soils. *Soil Science Society of America Journal* 36. (3): 465–472.

Thiemens, M.H. 1999. Mass-independent isotope effects in planetary atmospheres and the early solar system. *Science* 283. (5400): 341–345.

Trumbore, S.E., Sierra, C.A. and Hicks Pries, C.E. 2016. Radiocarbon nomenclature, theory, models, and interpretation: Measuring age, determining cycling rates, and tracing source pools. In *Radiocarbon and Climate Change*. Eds.: Schuur, E.A.G., Druffel, E.R.M. and Trumbore, S.E., Cham, Springer International Publishing, 45–82.

Turnbull, L., Brazier, R.E., Wainwright, J., Dixon, L. and Bol, R. 2008. Use of carbon isotope analysis to understand semi-arid erosion dynamics and long-term semi-arid land degradation. *Rapid Communications in Mass Spectrometry* 22. (11): 1697–1702.

Wang, J., Sun, J., Xia, J., He, N., Li, M. and Niu, S. 2018. Soil and vegetation carbon turnover times from tropical to boreal forests. *Functional Ecology* 32. (1): 71–82.

Werner, C., Schnyder, H., Cuntz, M., Keitel, C., Zeeman, M.J., Dawson, T.E., Badeck, F.W., Brugnoli, E., Ghashghaie, J., Grams, T.E.E., Kayler, Z.E., Lakatos, M., Lee, X., Máguas, C., Ogée, J., Rascher, K.G., Siegwolf, R.T.W., Unger, S., Welker, J., Wingate, L. and Gessler, A. 2012. Progress and challenges in using stable isotopes to trace plant carbon and water relations across scales. *Biogeosciences* 9. (8): 3083–3111.

Werth, M. and Kuzyakov, Y. 2009. Three-source partitioning of CO2 efflux from maize field soil by ^{13}C natural abundance. *Journal of Plant Nutrition and Soil Science* 172. (4): 487–499.

Werth, M. and Kuzyakov, Y. 2010. ^{13}C fractionation at the root-microorganisms-soil interface: A review and outlook for partitioning studies. *Soil Biology and Biochemistry* 42. (9): 1372–1384.

Yamashita, T., Flessa, H., John, B., Helfrich, M. and Ludwig, B. 2006. Organic matter in density fractions of water-stable aggregates in silty soils: Effect of land use. *Soil Biology and Biochemistry* 38. (11): 3222–3234.

Zach, A., Tiessen, H. and Noellemeyer, E. 2006. Carbon turnover and carbon-13 natural abundance under land use change in semiarid savanna soils of La Pampa, Argentina. *Soil Science Society of America Journal* 70. (5): 1541–1546.

Zhang, Q., Wu, J., Lei, Y., Yang, F., Zhang, D., Zhang, K., Zhang, Q. and Cheng, X. 2018. Agricultural land use change impacts soil CO_2 emission and its ^{13}C-isotopic signature in central China. *Soil and Tillage Research* 177. 105–112.

Zollinger, B., Alewell, C., Kneisel, C., Meusburger, K., Brandová, D., Kubik, P., Schaller, M., Ketterer, M. and Egli, M. 2014. The effect of permafrost on time-split soil erosion using radionuclides (^{137}Cs, $^{239+240}Pu$, meteoric ^{10}Be) and stable isotopes ($\delta^{13}C$) in the eastern Swiss Alps. *Journal of Soils and Sediments* 15. (6): 1400–1419.

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The Devdoraki Glacier catastrophes, Georgian Caucasus

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Abstract

This study analyses the Devdoraki Glacier surge type catastrophes since 1776, lead to human casualties, destruction of settlements and the international road in the Georgian Caucasus. According to archival data, at least six ice and ice-rock avalanches fell from the Devdoraki Glacier onto the Tergi (Terek) River valley during the period 1776–1876, the largest on June 18, 1776 and on August 13, 1832. The first blocked the Tergi River for three days and was breached catastrophically; the second was ~100 m high and ~2 km wide and its breach started after 8 hours. The most recent hazard occurred on May 17, 2014 killing nine people, and destroyed the Trans-Caucasus gas pipeline, Dariali Hydropower Plant (HPP) and international road. Using aerial and satellite imagery – Landsat, ASTER, SENTINEL, PLEIADES along with the 30 m resolution Advanced Spaceborne Thermal Emission and Reflection Radiometer Global Digital Elevation Model (ASTER GDEM; 17 November 2011) we have reconstructed this event. On the basis of subsequent detailed field observations, new geological and tectonic maps of the study region have been compiled. After that collapse we have registered ~180 m advance of the Devdoraki Glacier snout between 2014 and 2015, which was mostly caused by rock-ice avalanche deposits. This part of the glacier should be monitored continuously as it can raise debris flow activity in the future. We consider the main hypotheses behind these events, namely a) tectonic and seismic, b) permafrost, c) volcanic and d) morphological factors; interpret the data for mechanisms and velocities of the catastrophic movement and argue that the 2014 event should not be classified as a glacier surge, although the possibility of similar glacial surges can not be excluded. The Kazbegi-Jimara massif should be considered as a natural laboratory that enables the investigation of rock-ice avalanches and glacial mudflows.

Keywords: glacial hazard, rock-ice avalanche, debris flow, Devdoraki Glacier, surging glacier, Greater Caucasus

Introduction

Glaciers respond to changes in climate, translating the climatic signal into clearly observable changes in the landscape (Oerlemans, J. 2005). The global trend of glacier retreat in reaction to global climate change (IPCC, 2013) has implications for both ecosystem functions and human development. Glaciofluvial deposits transported by meltwater runoff are an important input for aquatic ecosystem biodiversity (Muhlfeld, C.C. *et al.* 2011). Mountain meltwater runoff is also an important water source for downstream populations at scales ranging from small communities to large metropolitan centers (Lutz, F. *et al.* 2014).

Natural disasters that have become more frequent due to climate change are often related to mountain glaciers. These are known

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as glacial hazards, which are highly dangerous and unpredictable natural hazards, but characteristic of many mountain regions (Evans, S.G. and Clague, J.J. 1994). They pose threats to population, infrastructure, human activities and economic development. The earliest known evidence of devastating glacial hazards in the Alps dates back to medieval times (Richard, D. and Gay, M. 2003). Glacial hazards include outbursts from moraine and glacier-dammed lakes, glacier avalanches, and landslides/debris flows in the glacier environment. These events have taken place more recently in the context of dramatic retreat of glaciers in response to climate change (Dyurgerov, M.B. and Meier, M.F. 2000). It is expected that the frequency, and in some cases the magnitude, of glacial hazards will increase due to global warming and consequent glacier retreat (Reynolds, J.M. 2003).

Glacier disasters are widespread in the Greater Caucasus, involving the detachment of large glacier masses (several million m^3) and their rapid movement down valleys, with speeds of tens of metres per second for distances up to tens of kilometres. Sometimes they reach the scale of debris flow disasters, leading to large changes in valley floors, significant damage to infrastructure and casualties. The Kazbegi-Jimara massif has a long record of such extreme rock-ice avalanches and glacial mudflows *(Figure 1).*

The largest ice-rock avalanche was recorded on 20 September 2002 on the Russian side (North Ossetia) of the mountain. On the north-eastern face of Mt. Kazbegi, ~150 million m^3 of rock and ice failed and fell onto Kolka Glacier, triggering an ice-rock-debris flow down the valley with speeds up to 80 m/sec. More than 100 people were killed (Evans, S.G. *et al.* 2009).

On May 17 2014 at 09:33 a.m. in the Dariali (Tergi) gorge (Georgian Caucasus, Kazbegi region), in the confluence of the Tergi and Amali (Devdoraki) rivers, a catastrophic rock-ice avalanche and glacial mudflow took place blocking the strategic infrastructure of the country *(Photo 1).* The Trans-Caucasus gas pipeline and hydropower plant were damaged. Mudflow damaged the high-voltage power transmission tower, the border guard base was isolated from the outside world, as well as the customs checkpoint and residence of the Patriarchate of Georgia. The disaster resulted in the death of nine people. About 200 people were evacuated by helicopter from the border crossing checkpoint and nearby areas. Thus, scientific study of this natural disaster is of practical importance.

In this article we present the Devdoraki Glacier change and glacial disasters which have occurred since 1776 and reconstruct/analyze the latest glacial hazard on 17 May, 2014.

Study area

The Kazbegi-Jimara massif is second only to the Elbrus as a modern glaciation area in the Caucasus region (Tielidze, L.G. and Wheate, R.D. 2018), and is the heart of glaciation in the Tergi River basin, located in the northern Greater Caucasus (Tielidze, L. 2017). Kazbegi (Mkinvartsveri) is a dormant volcano which has a principal double cone and several side cones. The main cone erupted about 185,000 ± 30,000 years ago, while the side cone of New Tkarsheti erupted about 6,000 years ago (Chernyshev, I.V. *et al.* 2002). In view of present volcanic activity Mt. Kazbegi can be regarded as dormant. Geochemical observations and analyses suggest the proximity of magmatic bodies indicated by degassing of magmatic reservoirs (Polyak, B.G. *et al.* 2000). The Kazbegi-Jimara slopes generate valley type glaciers: Mydagrabyn, Maili, Kolka (Russia), Suatisi, Mna, Gergeti, Abano, Chachi and Devdoraki (Georgia). The hanging-valley type Devdoraki Glacier (4.40 ± 0.12 km^2) is known for its powerful rock-ice avalanches in 18^{th}-21^{th} centuries.

The geological structure of the region involves intrusive and metamorphic rocks of Paleozoic age and Jurassic sediment and weakly metamorphic rocks as well as Quaternary volcanic, alluvial, deluvial, proluvial, colluvial and glacial sediments (Tielidze, L.G. *et al.* 2019) *(Figure 2).*

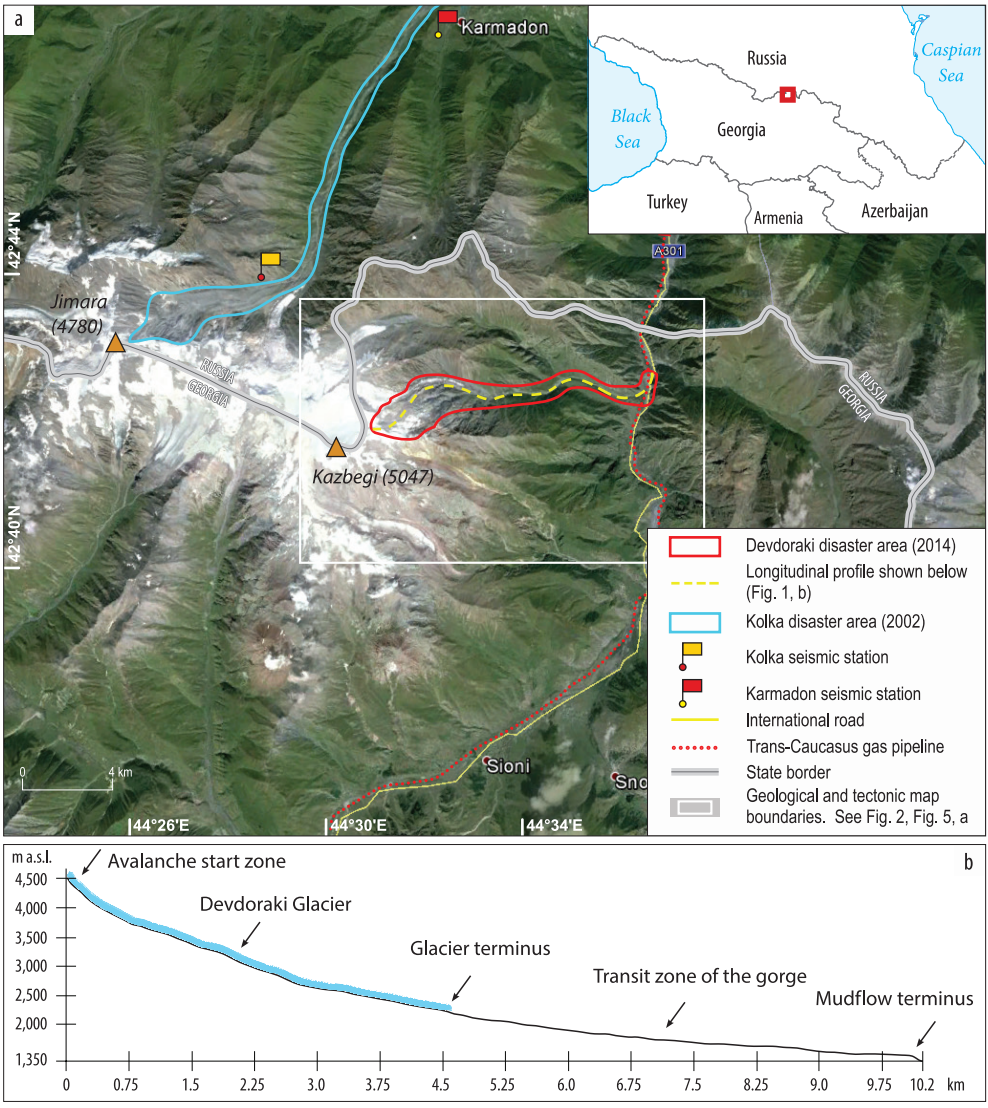

Fig. 1. Location of study area (a): Mt. Kazbegi (42°43′ N, 44°34′ E). *Source*: Google Earth imagery, 17 Sept. 2016. Longitudinal cross section along the avalanche and distal mudflow track (b). *Source*: Based on ASTER GDEM, 2011.

Jurassic sediments are widely represented, in which researchers have highlighted and studied lithofacial suites of different ages (Topchishvili, M.V. *et al*. 2006). The oldest is the Sinemurian (J1s) suite of Khde (Kistanka), which is constructed from weakly metamorphic thin layered sandstone (aspid) slates of flyschoid texture, quartzites, gravelites and occasional middle layers of conglomerate.

The volcanogenic massif of Kazbegi (Dzotsenidze, N. 1985) has generated the lava flows of Tsdo and Chachi and two branches of the Khde flow – the Amali and Gveleti flows. Exogenous-continental sedi-

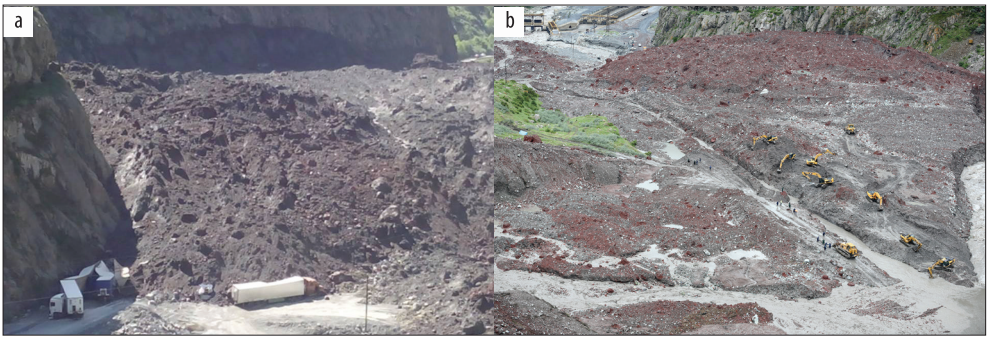

Photo 1. Mudflow terminus area and damaged international highway on 17 May 2014 (a), and 18 May 2014 (b). (Photo by INTERPRESSNEWS).

ments are represented by genetical diversity in lithological composition and origin, such as glacial, deluvial, proluvial, colluvial and lahar formations (Kipiani, I. *et al.* 1983). This tectonically active area features geothermal activity, including several hot springs in the area of the Kazbegi massif, revealed by field observations (Polyak, B.G. *et al.* 2000) and (Zautashvili, B. and Mkheidze, B. 2012).

The climate above 3,400 m a.s.l. is moderately humid around the Kazbegi massif. Two zones are distinguished: the nival (3,400–4,300 m) and glacial (above 4,300 m). The average annual precipitation is 1,000–1,200 mm. The number of days with precipitation amounts to 170 per year, falling only as snow in the glacial zone. The mean winter temperature is –10 °C and the mean summer temperature is 2.2 °C in the nival zone. The mean wind speed is 6.2 m/sec, with an average number of 12 stormy days per month in winter (Nakhutsrishvili, G. *et al.* 2005).

History of disasters

The surging-type Devdoraki Glacier was probably the most famous glacier of the Greater Caucasus in the 19th century. The well-known "Kazbegi blockages" stopped transportation between Russia and Georgia, which at the time had just joined the Russian Empire. The first recorded significant "collapse" occurred in June 1776. The valley of the Tergi River was blocked for three days, a temporary lake formed, before the dam was broken, flooding several *auls* (mountain villages), even at a height of ~76 m above the river. This blockage was first described by Reyneggs, D. (1884).

There was no official information about the blockage in 1817. There is only a brief note from General Ermolov's diary: "In October, the collapse of the mountains of the Caucasus snow crashed. At first its height was ~80–100 metres. The flow of the Tergi River was stopped for almost 24 hours. The ice mass did not melt even after a year" (Reyneggs, D. 1884).

There is more information about the blockage of 1832. An ice mass in the night from August 12 to August 13 blocked the Tergi River between the Gveleti Village and Khde River confluence (~2.2 km long). The river flow was stopped for 8 hours. The collapsed ice mass was ~100 m in height in the Tergi River valley and ~15 million m^3 in a volume. The total deposited volume, including the Amali River valley amounted to 22 million m^3 (Dinik, N.Ya. 1890). It was a much greater amount than usual for glacier avalanches in the Alps (Heybrock, W. 1935). The road was restored from the dam after two years, and completely blocked up again only five years later (Dinik, N.Ya. 1890).

Since 1832, several new blockages were forecasted, but either the ice-debris masses did not reach the Tergi River or the fore-

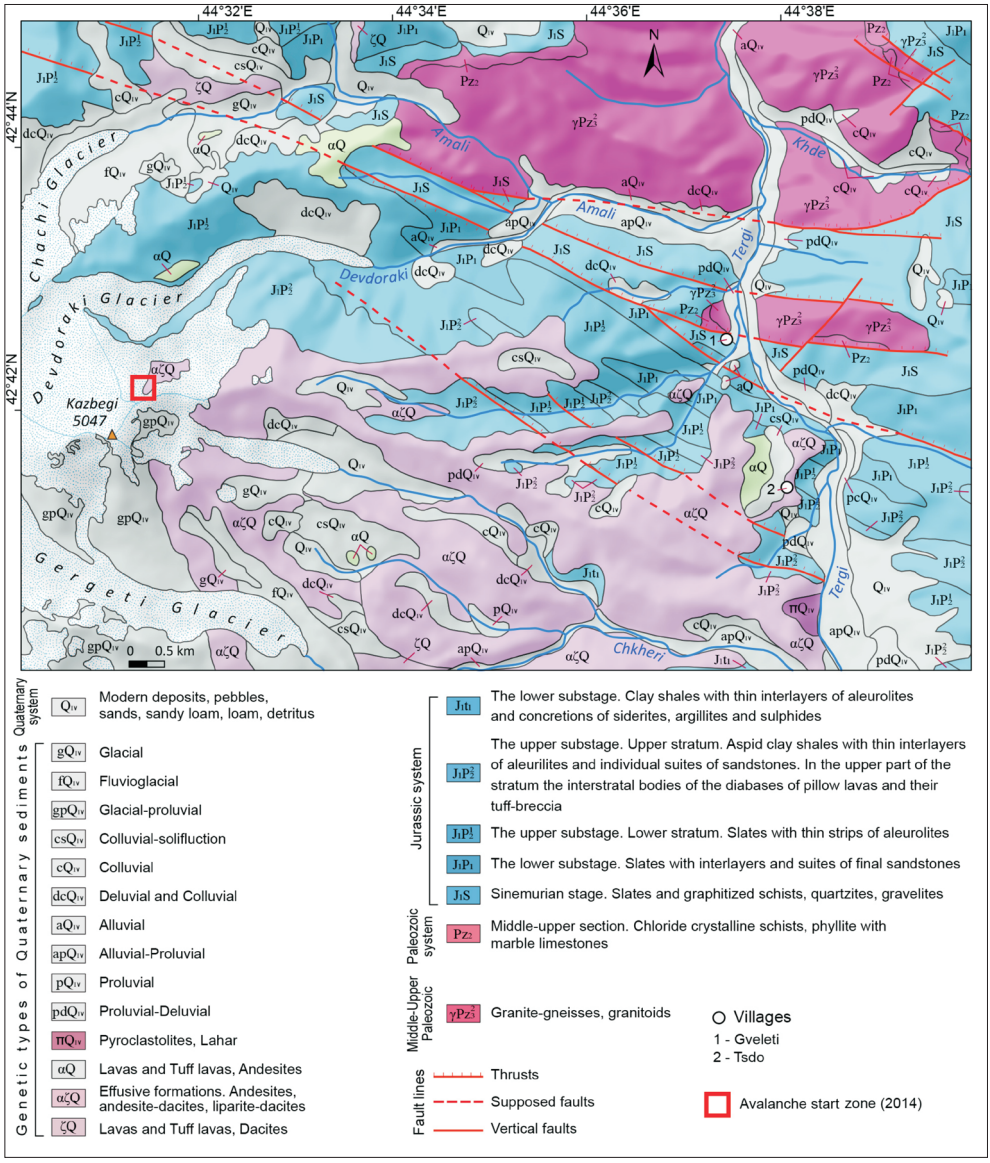

Fig. 2. Updated geological map of the study region based on 1: 50,000 scale geological map (k_38_42_v, 1983). For the map boundaries see *Fig. 1.*

casts failed altogether. E.g. in 1866–1867 the Devdoraki Glacier advanced, raising alarm and forcing researchers to monitor its position. But the blockage was developed slowly and the Tergi River valley was not blocked (Statkowsky, B.I. 1877) *(Figure 3).*

In 1876, again there was a danger of a blockage, since the glacier greatly increased and advanced by ~150 metres *(Figure 3,* c*).* The true cause of these blockages would be easy to find if we had accurate information about the phenomena that preceded the ob-

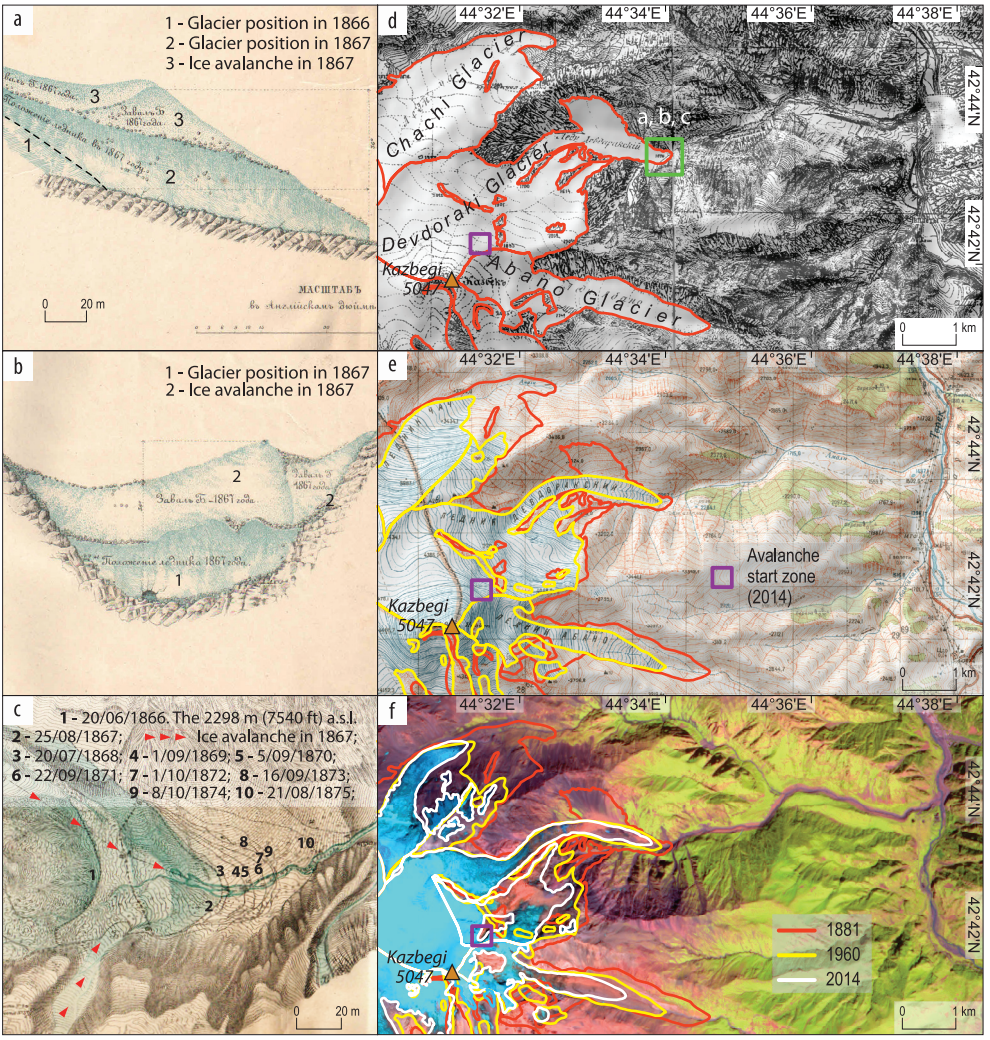

Fig. 3. The Devdoraki Glacier longitudinal profile (a) in 1866–1867; its transversal profile (b) in 1867 by Statkowsky, B.I. (1877). The Devdoraki Glacier advance (c) in 1866–1875 by Dinik, N.Ya. (1890). The Chachi, Devdoraki and Abano glaciers reduction in 1881 (d) on military topographic map (1: 42,000); in 1960 (e) on military topographic map (1: 50,000); and between 1881 and 2014 (f) by Landsat 8 (28 August 2014).

structions and accompanied them: "we do not know exactly what is most important, which part of the glacier breaks, only the lower end of it falls or … those ice that lie much higher ... do not know if the ice remains in the valley after the collapse ... and what is at that time a glacier. There are only conjectures and hypotheses" (Dinik, N.Ya. 1890).

Vardanyants, L.A. (1932), analyzed the causes of the discharges of the Devdoraki Glacier, as well as the Genaldon disaster of 1902 on the Kolka Glacier. He believed that they were caused by earthquakes and formed by the landslides of the "hanging floor" characteristic of the Kazbegi massif glaciers. According to the observations of 1926–1928 he

noted that on many glaciers the feeding area is interrupted by an "ice wall hanging over a steep rocky cliff" about 50 m thick, from which "whole ice bands must come off" during earthquakes. In addition, he concluded that water didn't play a significant role. As the Devdoraki Glacier has an area of about 9 km^2, an avalanche of this order would require a precipitation of ~3,000 mm during the year, which is improbable in the Kazbegi region.

Information on further observations of the Devdoraki Glacier, up to the first decade of the 20th century, is given in the work of Dukhovskiy, A.I. (1915), who investigated the state of other glaciers of the Kazbegi massif, where collapses or movements also occurred – Abano, Mna, Gergeti and Chachi. Panov, V.D. (1993) later used Dukhovskiy' s data on the fluctuations of the Devdoraki Glacier in 1863–1893 and 1905–1912. After 1885 the glacier experienced fluctuations, and the advances of its terminus occurred repeatedly, for example, in 1886–1887, as well as in 1893–1904, when the glacier advanced by 45 and 55 m respectively. As a result, over the entire period from 1881 to 1970, the glacier retreated by only 16 m (Panov, V.D. 1993). However, two topographic maps from 1881 and 1960 showed a major glacier retreat of ~190 m (*Figure 3,* d, e*)*. Overall we have measured ~400 m terminus retreat between 1881–2014 (before the collapse) (*Figure 3,* d–f*)* and ~75 m and ~180 m advance phases between 2002–2006 and 2014–2015.

In the 1960s, much work was devoted to the study of the glaciers of Kazbegi massif by Tsomaia, V.Sh. (1980). According to his investigation the Devdoraki was the fastest moving glacier in the Caucasus. While most Caucasus glaciers were retreating, the Devdoraki Glacier snout was stationary between 1912 and 1960s and even advanced in 1969–1979. He believed that this advance, also observed on other Kazbegi massif glaciers, was associated with a large accumulation of precipitation in the firn areas in 1955–1970. As for the causes of the previous debris flow, Tsomaia supported the opinion of Statkovsky, B.I. (1877), that the free passage of the ice into the narrow gorge of the Devdoraki River was hindered. As advance continued, the ice accumulated to such a thickness in the gorge that a temporary dam was formed. The water held behind this barrier eventually burst through, carrying large amounts of ice and rubble. Tsomaia considered the possible danger of new blockages. Subsequently, there were many expeditions and investigation from the 1960s to 2017 (Asoyan, D.S. and Rototaeva, O.V. 2016).

Data and methods

Large-scale topographic maps (1: 42,000) from the second Caucasus topographic survey (1880–1910) were used to evaluate the Devdoraki Glacier outline *(Table 1).* The oldest topographic maps were replaced in 1960, under the former Soviet Union with 1: 50,000 scale topographic maps from 1950 to 1960 with a contour interval of 20 m. We used these 1960s georeferenced maps from the latest Caucasus glacier inventory (Tielidze, L.G. and Wheate, R.D. 2018). As the 1880s maps were only available in printed form, we scanned these at 300 dpi with 7 m ground resolution and co-registered using the 11 July

Table 1. List of the maps and satellite images scenes used in this study.

Year, date	Resolution, m	Type of imagery/map	Scene ID
1881	7	1: 42,000 topographic map	222_26_II
1960	5	1: 50,000 topographic map	k_38_42_v
1983	7	1: 50,000 geological map	k_38_42_v
16.05.2014	15	ASTER	AST_L1T_00305162014080121_20150621034017_9465
11.07.2014	5–30	Landsat 8	LC81700302014192LGN00
18.05.2014	2	PLEIADES	PL1A_20140518_081358

2014 Landsat 8 image as a master (Tielidze, L.G. 2016). Offsets between the images and the archival maps were within one pixel (15 m) based on an analysis of common features identifiable in each data set. We re-projected maps in Universal Transverse Mercator (UTM) coordinates, zone 38N on the WGS84 ellipsoid, to facilitate comparison with modern image data sets.

High-resolution satellite instruments such as Landsat L8 OLI/TIRS (Operational Land Imager and Thermal Infrared Sensor), with 15–30 m horizontal resolution available since 2013, and Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) imagery with 15 m resolution available since 2000, and others of their class help in recognizing important details of natural hazards; e.g., avalanche and debris-flow traces, glacier crevasses, and lakes and their changes over time (Kääb, A. 2002; Kääb, A. *et al.* 2003).

We have used an ASTER satellite image captured one day before the disaster in cloud free weather conditions on 16 May 2014 and Landsat 8 image approximately two months after the disaster in partially cloudy weather on 11 July 2014. Georeferenced images were downloaded using the EarthExplorer (http://earthexplorer.usgs.gov/) and Reverb/ECHO tools (http://reverb.echo.nasa.gov/). We used the Landsat 8 panchromatic band, along with a colour composite scene for each acquisition date, combining shortwave infrared, near infrared and red for Landsat, and near-infrared, red and green for ASTER images. For both Landsat and ASTER images we used pan-sharpened tools in ArcGIS 10.2.1 software.

We used the 2 m resolution PLEIADES 1A multispectral (Blue, Red, Green and Near Infrared) imagery for post event analysis (http://scanex.ru/). The PLEIADES 1A sensor was launched in December, 2011. Like other 0.5 m resolution sensors, this satellite sensor collects both panchromatic and RGB and NIR (2 m) multispectral data, and is a great option for site monitoring or change detection analyses.

The 30 m resolution ASTER Global Digital Elevation Model (GDEM, 17 November 2011) was used to determine slope and hypsometric profile from the Rock-ice avalanche up to its final stop. The DEM has been downloaded from NASA LP DAAC Collections (http://earthexplorer.usgs.gov/).

In addition, we used the large scale (1: 50,000) geological map created in 1983. We conducted several field trips to detail geomorphological and geological survey over the last years. Based on field information and the geological map, we created modern geological and tectonic maps of the study region.

We used the global permafrost zonation index map by Gruber, S. (2012), in order to observe the relationship between the last glacier avalanche and permafrost intensity.

Reconstruction of the 17 May event

On the ASTER image from 16 May 2014, the start zone of the rock-ice avalanche was already unstable, because a trace of rock fall is observed *(Figure 4,* a*).* The result of the disaster is shown on the Landsat image from 11 July 2014 *(Figure 4,* b*)* and on the PLEIADES image from 18 May 2014 *(Figure 4.* c*).* The field data and aerial images from the helicopter enabled us to reconstruct the event.

Unlike phenomena which occurred in the gorge in the past, when ice masses were detached from the glacier terminus, the rock-ice avalanche formation zone of 2014 is located at a relatively high benchmark, at a height of ~4,500 m on the steeply inclined (60–75°) north-east slope of the Kazbegi peak *(Photo 2,* a, b*).* In the south-eastern part of the Devdoraki Glacier's feeding zone, the rock-avalanche involved rock and glacier components among large snow masses (NEA 2014). The collapsed mass was transformed into the rock-ice avalanche, which was divided into three flows and rushed down the steep ice-tongue surface at high speed *(Photo 2,* c, d*).*

One of the flows jumped over the rock ledge spraying the transformed mass onto the steep slope, but most of the material

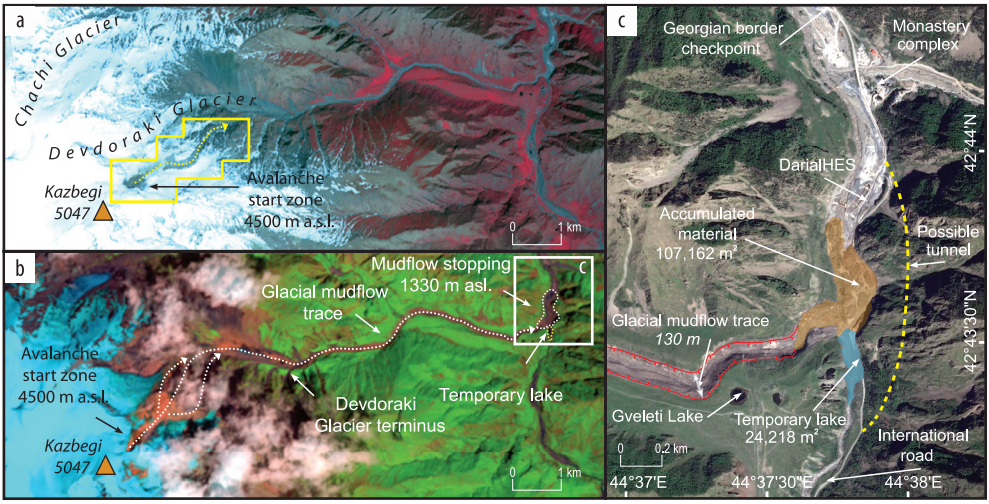

Fig. 4. ASTER image, 16 May 2014 (a); Landsat L8 image, 11 July 2014 (b); PLEIADES image, 18 May 2014 (c).

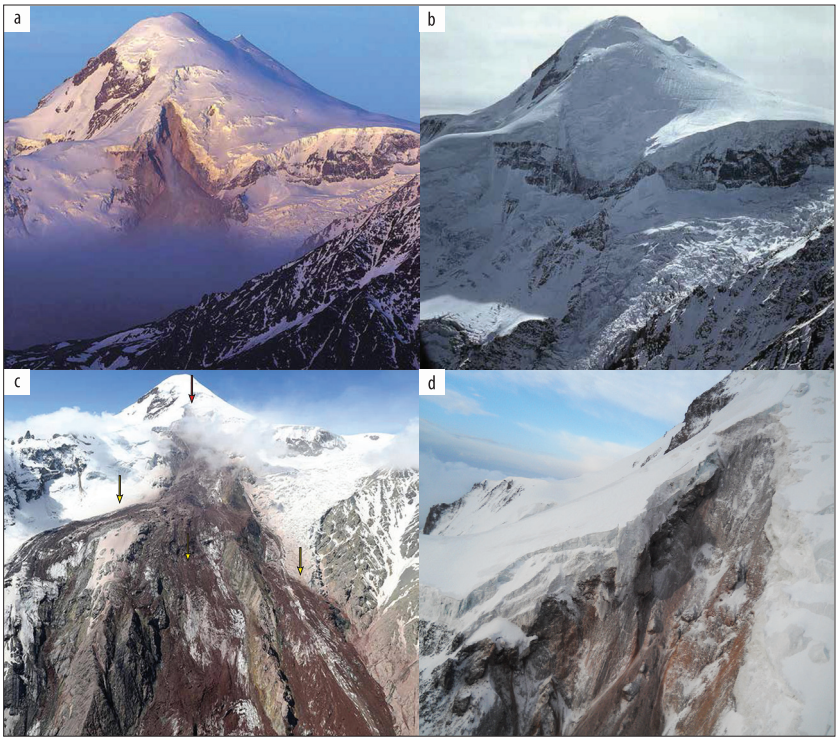

Photo 2. Mt. Kazbegi and the heart of rock-ice avalanche genesis on 17 May 2014 (a). An archive photo (1987) about the same site (b). A helicopter photo taken on 17 May 2014: red arrow shows avalanche start zone, yellow ones show the three flows of the rock-ice avalanche (c). Avalanche start zone close view 18 May 2014. Photos taken by: Gotsiridze, G. (a, c), Rototaeva, K.P. (b), Gaprindashvili, M. (d).

collapsed instantly into the glacier again. A reddish-pink trace was observed in the high benchmarks of the southern slope in the form of a large spot *(Photo 3,* a*)*. The largest flow placed the central part of the ice-tongue in the dynamic zone and this suffered strong deformation and fragmentation into distinct ice blocks (NEA 2014).

Below this section all flows were united in a single flow of grandiose volume and rushed down to the gorge at a high speed and in its way took away the glacier deposits and weathered material in the Devdoraki River bed and on its slopes.

After joining the Devdoraki and Amali rivers, the flow moved in the curved bed of the trapezoidal cross-section developed in the glaciofluvial-mudflow sediments, with an average depth of 20–25 m. In the Gveleti Lake meridian the river bed turns sharply to the north-east. In addition, the trapezoidal section's relatively wide bed transforms instantly into a narrow "V"-shaped cross-section bed, and its throughput is considerably limited. Therefore, in the location of a sharp bend the short-term uneven temporary damming of the mudflow took place. Due to the temporary damming of the flow, its driving force increased and the flow was thrown in the direction of the confluence of the Tergi River, reaching the rocky cliff composed of granitoids and deposited solid material transported by the mudflow at its foot. In addition, part of the flow began flowing to the northward and stopped about 100 m away from the hydro-technical building of the Dariali HPP (NEA 2014). The maximum speed of the flow could be 130 m/sec (Zaalishvili, V.B. *et al.* 2018).

As a result of accumulation of solid sediment transported by mudflow, a powerful debris cone occurred (~1.5 million m^3 in volume) (NEA 2014), which completely blocked the Dariali gorge (*Photo 3,* b*)*. From the wall

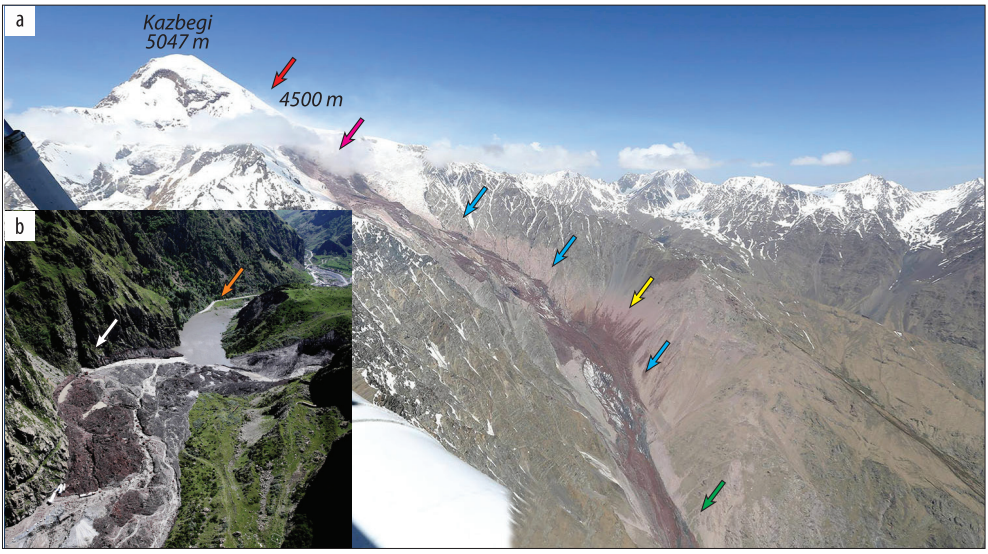

Photo 3. A helicopter photo taken on 20 May 2014 (a): red arrow indicates the origin of rock-ice avalanche; purple arrow shows accumulated material in the separation cirque area; yellow arrow shows the spraying place of the transformed material; blue arrows show accumulated material in the Devdoraki ice-tongue area; green arrow shows accumulated material in the transit zones of the gorge. Tergi (Dariali) gorge, the result of glacial-mudflow (b): white arrow shows the Dariali HPP transport tunnel from which the accumulated water flow discharged; brown arrow shows the temporary lake. Photo by Gotsiridze, G.

of separation up to the Tergi River confluence, the overall volume of the withdrawn mudflow mass was ~5–6 million m^3 (NEA 2014), most of which accumulated in the area of the separated cirque and in the Devdoraki ice-tongue and transit zones of the gorge *(Photo 3,* a*).*

Overall, the Devdoraki glacial debris rock-mudflow was characterized by high density, without which and the corresponding geological nature it would be impossible to bring down large boulders (3–6 m). Moreover, even after the entry into the main river bed, the Tergi River could not provide the liquefaction of the rock-mudflow and transfer to the downstream of the river (NEA 2014). In the first stage of the accumulation of debris flow in the Tergi River gorge, the important positive role played by the transport tunnel of Dariali HPP in the passage of the dammed water flows is notable *(Photo 3,* b*).* If the water had not discharged from the temporary lake through a transport tunnel, we would have faced more catastrophic consequences.

The mudflow after its entry into the Dariali (Tergi) gorge blocked the Tergi River for some hours and a 20–30 m depth lake was created *(Photo 3,* b*),* with volume of at least 150,000 m^3. The fall from the heart of rock-ice breaking to Dariali gorge (place of accumulated material) is ~3.2 km, while the distance is ~10.2 km (see *Figure 1*, b). The disaster had a devastating effect over such a large inclination and distance.

At that time, Gudauri, the nearest seismic station (30 km away) from the Georgian side, recorded a 1.7 magnitude earthquake two days earlier and several hundred small quakes between 17 and 19 of May. The entire process of the movement of the avalanche flow was recorded by seismic stations of the Karmadon Parametric Range located on the Russian side in close vicinity (~14 km) to the transit zone. Records of the station Kolka (7 km away) confirmed the time of the beginning of the collapse with an accuracy of fractions of seconds (Zaalishvili, V.B. *et al.* 2018). Location of the seismic stations is shown in *Fig. 1.* (a).

Discussion

Avalanche triggered by tectonic and seismic movement

Recent studies confirmed that the Devdoraki Glacier system is located within the neo-tectonic Shauhokh-Kazbegi morphostructure, developed on the left bank of the Tergi River and located at the intersection of the two largest faults and crushing zones, with which active neo-tectonic uplifts are associated (Gamkrelidze, I.P. 2000).

In the short valleys of the lateral tributaries of the Tergi with steep longitudinal profiles confined zones of short faults, mud-stone mudflows periodically descend, and on the slopes of valleys there are intensive landslide processes. Tectonic movements intensify the activity of gravitational and glacial processes can play a role in the movement of the Kazbegi glaciers over the last two centuries *(Figure 5,* a*).*

Comparison of recorded periods of seismic disturbance with major avalanches in the Caucasus region over the last two centuries (Mushketov, I. and Orlov, A. 1893) shows that several earthquakes occurred in 1830–1832, 1840–1842, and 1853–1856, at the time of the Kazbegi glaciers avalanches. The first period brought 17 known earthquakes to the Caucasus, the second more than 50, and the third between 30 and 40. No earthquakes at the time of the earlier avalanches of the Devdoraki Glacier have been recorded. However, southern Caucasus was not annexed by the Russian empire until 1801, and the accumulation of seismological data was naturally a gradual process. It seems possible that these earlier ice avalanches were associated with unrecorded earthquakes.

A hot spring near the Kazbegi massif adds further support to the seismic theory. Variation in both its quality and its volume, observed only a few hours before the Kolka Glacier catastrophe, observed in 1902 by inhabitants of the Genaldon Valley (Heybrock, W. 1935), suggests a close relationship between the zone of fracture, earthquake, and glacier avalanche.

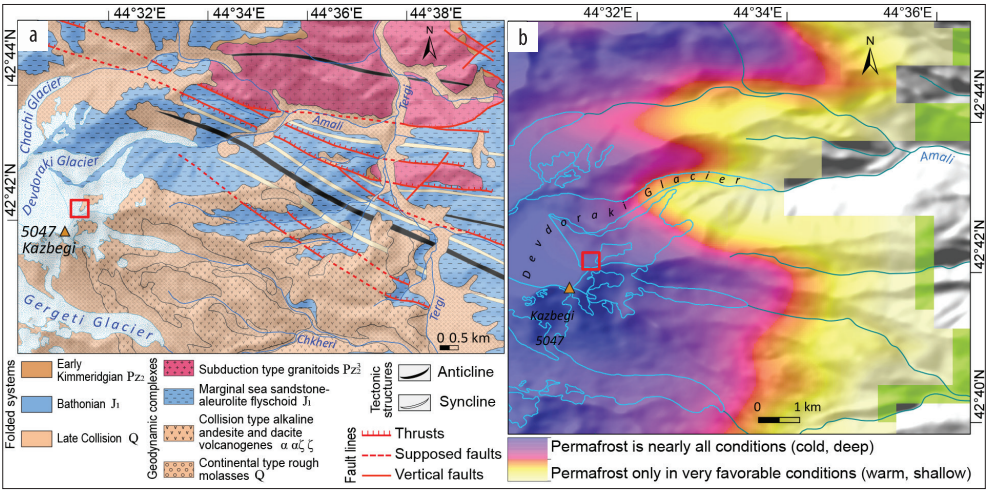

Fig. 5. Tectonic map* of the study region (a) compiled by the authors. Permafrost zonation index map (b). *The map boundaries are shown in *Fig. 1.*

In recent years, several volcanic tremors were recorded in the Mt. Kazbegi region (Tobler, S. and Meier, L. 2015). Such tremors may again induce slope failures on parts of the Mt. Kazbegi headwall.

Avalanche triggered by permafrost and volcanic activity

The global permafrost zonation index map (Gruber, S. 2012) shows that the avalanche start zone is located within an area of permafrost occurrence *(Figure 5,* b*).* Slope failure progressively induced by long-term degradation of permafrost is probably due to climate change (Tobler, S. and Meier, L. 2015). Degradation of permafrost can significantly reduce cohesion along frozen joints within a rock slope, causing it to destabilize.

In the aerial photographs taken on 17 May 2014 immediately after the collapse of the firn (*névé*) field, clouds of whitish gas flowing along the exposed cliffs of the focal region are clearly seen *(Figure 6, a).* On close examination, it can be asserted that these are not dust clouds and they are expelled directly from local exits in the rock substrate, i.e. fumaroles. A few hours later the emanations of gas disappeared. It is possible that the activation of fumarolic emanations occurred somewhat earlier. The outputs of the non-cold gas of endogenous nature on the contact of the rock substrate with the ice-firn field were accompanied by the development of thermokarst. As this destructive process continues, the hanging ice-firn massif lost its integrity and as a consequence – strength, which led to its shedding.

These results correlate well with local people, who felt the smell of sulfur few minutes earlier before the event. However, changing tensions often provoke secondary rock-fall events on a smaller scale during the days following the main event. Such secondary rock-fall events, as well as small ice detachments from the overlaying glacier can produce dust (Tobler, S. and Meier, L. 2015). Changing tensions within the rock mass after big rock failures mass may be another explanation for the visible cloud.

Further evidence of possible fumaroles is provided by ASTER imagery captured the previous day. Thermal data indicate that melting conditions had then been approached *(Figure 6,* b*).* Thus, we can argue that the latest event is not related to the glacier surge. It was most

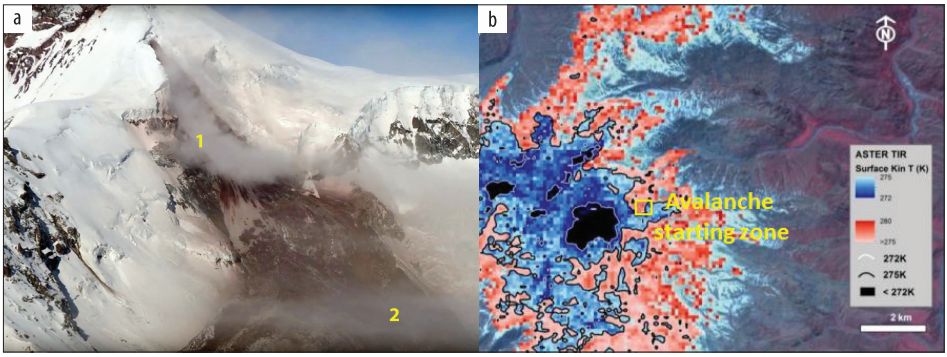

Fig. 6. Possible fumarolic emanations (a) on the north-east slopes of the Kazbegi volcano, 17 May 2014. – 1 = fumaroles; 2 = stable cloud of whitish gas (presumably sulfurous). *Source*: Photo by Ilia State University. ASTER imagery (b) a day before (16 May 2014) the disaster (Chernomorets, S.S. 2016).

likely caused by permafrost or local heat inflow from the Kazbegi massif. We note that direct evidence of such an opinion is critical for various reasons and requires more detailed investigation in the future.

Avalanche triggered by slope and glacier morphology

Analyzing the ASTER GDEM shows that the slopes of the volcanic massif of Kazbegi are sharply inclined (35–60°) up to the 3,000 m asl. This inclination causes a higher percentage (63.8%) of hanging type glaciers in the Tergi River basin, more than other river basins in Georgia (Tielidze, L.G. 2016). Thus, the morphographic factor is also likely to have some influence. The mechanical fracturing of glaciers is frequent in the region, accelerating intensity of melting, one of the supporting factors for rock-ice avalanches.

A possible reason for the Devdoraki surging is determined by the morphology of the glacier. An extensive relatively shallow feeding area, located at altitudes of ~4,000–4,700 m, continues below with a steeply dipping huge icefall. The ice mass and speed of its movement here are high, but then the icefall sharply narrows, and the glacier enters a narrow gorge, which causes ice accumulation.

Conclusions

Analysis of all data obtained enables conclusions about the causes and presents a possible scenario of the event. The most important circumstance has been the unusually unstable dynamics of the Devdoraki Glacier since 1776. The premature surge of the glacier and huge scale of the catastrophe were provoked by a whole complex of factors. First, this region is characterized by active movement of morphostructural blocks separated by tectonic faults, high seismic risk and the critical tension of physical fields. During the last 100 years, in the Kazbegi seismic detection block, earthquakes of 7–8 magnitude intensity were observed in 1878, 1915, 1947, 1951 and 1992 (NEA 2014). Another triggering factor was volcanic activity; apparently this caused additional melting of the bottom of the glacier and certainly favored unusually active falls from the right wall above the glacier. The tectonic and geological structure of the region also played an important role: the Devdoraki Valley is situated in a zone of large sub-latitudinal faults where displacements of individual blocks and earthquakes are highly probable along with the different relation of the volcanic and sedimentary rocks to weathering agents. A direct trigger for the glacier surge might have been just another minor

fall, a small earthquake, or simply a destructive process inside the glacier that created a critical tension in its body.

We note that after these examinations there is a high possibility of future earthquakes and accompanying glacier avalanches in the Kazbegi region. Accordingly, future research should focus on using high resolution aerial/satellite imagery and more detailed field measurements e.g. modern seismic station installations, glacier velocity measurements, debris cover assessments, monitoring of the volcanic activity and permafrost degradation, in order to better understand how these factors are influencing glacier hazards.

To avoid serious consequences of glacier hazards we recommend to construct a road tunnel on the east (right) slope in the Tergi Valley *(Figure 4, c)* and to not continue the Dariali HPP construction, to mitigate the risk and avoid incidents including deaths in the future.

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REFERENCES

Asoyan, D.S. and Rototaeva, O.V. 2016. Devdoraki Glacier, Kazbek: history of studies of natural hazards in XIX and the beginning of XXI centuries. *Ice and Snow* 56. (2): 253–264. (in Russian) DOI:10.15356/2076-6734-2016-2-253-264.

Chernomorets, S.S. 2016. *The Kazbek glacial debris in the Caucasus*. Moscow, Moscow State University. (in Russian)

Chernyshev, I.V., Lebedev, V.A., Bubnov, S.N., Arakelyants, M.M. and Gol'tsman, Yu.V. 2002. Isotopic geochronology of Quaternary volcanic eruptions in the Greater Caucasus. *Geochemistry International* 40. (11): 1–16. (in Russian)

Dinik, N.Ya. 1890. *Modern and ancient glaciers of the Caucasus*. Tiflis, Zap. Caucasian Department of the RGO 14. (1): 282–417.

Dukhovskiy, A.I. 1915. *Observations of the Devdoraki Glacier in 1909–1912 in connection with the data on it from the 60th of the 19th century*. Tiflis, Izv. Caucasian Department of the RGO. 23. (1): 1–21.

Dyurgerov, M.B. and Meier, M.F. 2000. Twentieth century climate change: Evidence from small glaciers. *PNAS* 97. (41): 406–1411. DOI: 10.1073/pnas.97.4.1406.

Dzotsenidze, N. 1985. *Volcanic formations in the report "Geological description of rivers of Liakhvi, Ksani, Aragvi and Tergi"*. Geological funds. (in Russian).

Evans, S.G. and Clague, J.J. 1994. Recent climatic change and catastrophic geomorphic processes in mountain environments. *Geomorphology* 10. 107–128.

Evans, S.G., Tutubalina, O.V., Drobyshev, V.N., Chernomorets, S.S., McDougall, S., Petrakov, D.A. and Hungr, O. 2009. Catastrophic detachment and high velocity long-runout flow of Kolka Glacier, Caucasus Mountains, Russia in 2002. *Geomorphology* 105. 314–321. Available at: https://doi.org/10.1016/j.geomorph.2008.10.008

Gamkrelidze, I.P. 2000. *Again about the tectonic dismemberment of the territory of Georgia*. Tbilisi, GIN NA of Georgia. (in Russian)

Gruber, S. 2012. Derivation and analysis of a high-resolution estimate of global permafrost zonation. *The Cryosphere* 6. 221–233. DOI:10.5194/tc-6-221-2012.

Heybrock, W. 1935. Earthquakes as a Cause of Glacier Avalanches in the Caucasus. *Geographical Review* 25. (3): 423–429.

IPCC 2013. *Climate change 2013: The physical science basis. Contribution of working group I to the fifth assessment report of the Intergovernmental Panel on Climate Change*. Eds.: Stocker, T.F., Qin, D., Plattner, G-K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V. and Midgley, P.M. Cambridge, Cambridge University Press. DOI:10.1017/CBO9781107415324.

Kääb, A. 2002. Monitoring high-mountain terrain deformation from repeated air and space-borne optical data: examples using digital aerial imagery and ASTER data, ISPRS J. *Photogrammetry and Remote Sensing* 57. 39–52.

Kääb, A., Wessels, R., Haeberli, W., Huggel, C., Kargel, J.S. and Singh Khalsa, S.J. 2003. Rapid aster imaging facilitates timely assessment of glacier hazards and disasters. *Eos* 84. (13): 117–124.

Kipiani, I., Avramov, K. and Iordanishvili, A. 1983. *The report of the Kazbegi in two monks.* Geological funds. (in Russian).

Lutz, F., Immerzeel, W.W., Shrestha, B. and Bierkens, M.F.P. 2014. Consistent increase in high Asia's runoff due to increasing glacier melt and precipitation. *Nature Climate Change* 4. 587–592. DOI:10.1038/nclimate2237.

Muhlfeld, C.C., Giersch, J.J., Hauer, F.R., Pederson, G.T., Luikart, G., Peterson, D.P., Downs, C.C. and Fagre, D.B. 2011. Climate change links fate of glaciers and an endemic alpine invertebrate. *Climatic Change* 106. 337–345. DOI:10.1007/s10584011-0057-1.

Mushketov, I. and Orlov, A. 1893. *Katalog zemleteryaseni rossiiskoi imperii* (Catalogue of Earthquakes in the Russian Empire). Zapiski Imp. Russ. Geogr. Obshchestva po Obshchei Geogr. 26. (in Russian)

Nakhutsrishvili, G., Abdaladze, O. and Kikodze, A. 2005. *Khevi, Kazbegi Region*. Tbilisi, SCOPES Project No. GEPJ 062347.

NEA 2014. National Environmental Agency Report, 2014. *General condition of mudflow phenomena in the Tergi River upstream and the Report on the assessment of geodynamical conditions of the catastrophic glacial debris flow developed in the Dariali gorge on 17th of May of 2014.* Tbilisi, National Environmental Agency (in Georgian). Available at: http://nea.gov.ge/

Oerlemans, J. 2005. Extracting a Climate Signal from 169 Glacier Records. *Science* 308. 675–677. Available at: http://dx.doi.org/10.1126/science.1107046

Panov, V.D. 1993. *Evolution of the modern glaciation of the Caucasus.* Sankt Petersburg, Gidrometeoizdat.

Polyak, B.G., Tolstikhin, I.N., Kamensky, I.L., Yakolev, L.E., Marty, B. and Cheshko, A.L. 2000. Helium isotopes, tectonics and heat flow in the Northern Caucasus. *Geochimica et Cosmochimica Acta* 64. (11): 1925–1944.

Reyneggs, D. 1884. *Collection of information about the obstructions that fell from the mountain of Kazbegi from 1776 to 1878 on the Georgian Military Road*. Tiflis, Typography of the Chief Directorate of the Viceroy of the Caucasus and A. Mikhelson.

Reynolds, J.M. (ed.) 2003. *Development of glacial hazard and risk minimization protocol in rural environment.* Report No R7816. Reynolds Geo-Sciences Ltd. UK.

Richard, D. and Gay, M. (eds.) 2003. *GLACIORISK. Survey and prevention of extreme glaciological hazards in European mountainous regions.* EVG1 2000 00512 Final report (01.01.2001–31.12.2003). Available at: htpp://glaciorisk.grenoble.cemagref.fr

Statkowsky, B.I. 1877. *Origin of Kazbegi ice blockage and measures for its prevention.* Tiflis. (in Russian)

Tielidze, L.G. 2016. Glacier change over the last century, Caucasus Mountains, Georgia, observed from old topographical maps, Landsat and ASTER satellite imagery. *The Cryosphere* 10. 713–725. Available at: https://doi.org/10.5194/tc-10-713-2016

Tielidze, L.G. 2017. The new inventory and general description of the modern glaciers. In *Glaciers of Georgia. Geography of the Physical Environment*. Ed.: Tielidze, L.G., Cham, Springer. Available at: https://doi.org/10.1007/978-3-319-50571-8_3

Tielidze, L.G. and Wheate, R.D. 2018. The Greater Caucasus glacier inventory (Russia, Georgia and Azerbaijan). *The Cryosphere* 12. 81–94. Available at: https://doi.org/10.5194/tc-12-81-2018

Tielidze, L.G., Gobejishvili, R. and Javakhishvili, A. 2019. Eastern Greater Caucasus. In *Glaciers of Georgia. Geography of the Physical Environment*. Ed.: Tielidze, L.G., Cham, Springer. Available at: https://doi.org/10.1007/978-3-319-77764-1_10

Tobler, S. and Meier, L. 2015. *Georgia, Kazbegi-Devdoraki Area. Feasibility Study for Early Warning Systems.* Report Nr. 1414170.1.

Topchishvili, M.V., Lominadze, T.A., Tsereteli, I.D., Todria V.A. and Nadareishvili, G.Sh. 2006. *Stratigraphy of Jurassic deposits of Georgia.* Tbilisi, GIN NA of Georgia. (in Russian)

Tsomaia, V.Sh. 1980. *Snow transfers, pulsations of glaciers in the Caucasus mountains and their consequences. Dangerous hydro-meteorological phenomena in the Caucasus.* Sankt Petersburg, Gidrometeoizdat, 176–203. (in Russian)

Vardanyants, L.A. 1932. Geotectonics and geoseismics of Daryal as the main cause of catastrophic landslides of the Devdoraki and Genaldon glaciers of the Kazbegi Massif. *Izvestiya GGO* 64. (1): 51–60.

Zaalishvili, V.B., Melkov, D.A, Dzeranov, B.V., Morozov, F.S. and Tuaev G.E. 2018. Integrated instrumental monitoring of hazardous geological processes under the Kazbek Volcanic Center. *International Journal of GEOMATE* 15. (47): 158–163.

Zautashvili, B. and Mkheidze, B. 2012. *Mineral waters.* Chapter in the National Atlas of Georgia. Tbilisi, Publ. "Cartograpia". (in Georgian)

DOI: 10.15201/hungeobull.68.1.3 Hungarian Geographical Bulletin **68** 2019 (1) 37–50.

Public perception of urban identity in post-Soviet city: the case of Vinnytsia, Ukraine

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Abstract

This study deals with urban identity in Vinnytsia, one of the most economically vibrant Ukrainian cities, arguably known as a fiefdom of key Ukrainian power holders since the Euromaidan. Assuming that urban space may be treated simultaneously as a mirror and a factor of urban identity, the authors tried to look at urban identity under the lens of urban space transformations. The sociological survey conducted in 2016 and covering 168 respondents was focused on public representations about the city in whole and particular places in the city as well, including important recent changes of urban landscape. We came to conclusion that Vinnytsia represents an inclusive model of urban identity growing from additional actualized strata of historical memory. However, there is a stable core of identity, requiring a great deal of effort to be changed. We confirmed our hypothesis that identity-related discussions in Vinnytsia are centred on the issue of leadership, caused by current privileged position of the city and successful municipal reforms implemented by the local administration, and the issue of modernization, including aggressive commercialization, threating the historic urban landscape. The survey revealed the re-assessment of the role of industry as an element of local identity and demonstrated that the public requirements to the urban space experienced a strong shift towards human-friendliness, aesthetics, safety and diversity instead of political or ideological symbols. We observed pronounced shift to the local and regional values, although the connection with the national identity remains important. Finally, we came to conclusion that the success of transformation is largely defined by the possibility to painlessly combine new senses and connotations of places with the already existing. Thus, local identity may be considered as one of the key factors determining the perception of the urban space transformation, making urban landscape more resilient to the possible harmful impendences.

Keywords: urban identity, transformations, urban space, urban landscape, post-socialist city, Vinnytsia, Ukraine

Introduction

Cities under the Soviet rule were designed to glorify the ideas of communism. Subsequently, the authorities made all possible efforts to construct relevant urban identities: some aspects of already existing identities were artificially enhanced, other, on the contrary, silenced or completely erased. Nowadays, with a fall of communism, cities are once again rethinking their identities. This process is problematic and often contradictory, as it takes place under political, cultural and economic transition (Sýkora, L. 2009) and involves different actors like globalization process, national and regional governments, city administration, urban activists and ordinary citizens (Hein, C. 2012; Roșu, L. 2015).

The identity formation process implicates selection generalization and reinterpretation of history, including both tangible and intangible heritage, by multiple actors according to their goals (Semian, M. and Nováček, A. 2017). The ideological and political shift put into question the meaning of urban public spaces as an instrument for building local and national memories and identities (Molnár, V. 2013). Young, C. and Light, D. (2001), as well as Young, C. and Kaczmarek, S. (2008) point at three possible and poten-

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tially coexisting scenarios of modern identity building in different post-socialist cities, each shaped by different national contexts of the experience of socialism and post-socialism: they may (1) draw on pre-socialist "Golden Ages" as their key source of identity and seek to obscure the socialist period, or (2) draw on the history of the socialist period but utilize it more as a part of emphasizing their anti-communist credentials, or (3) may actively include some elements socialist past in highly contested ways in their contemporary identity formation. Anyway, the idea to enhance the "Europeanness" is in general use among post-socialist cities in different countries (McNeill, D. and Tewdwr-Jones, M. 2002; Gospodini, A. 2004; Young, C. and Kaczmarek, S. 2008).

Urban identity building reflects also interaction between hierarchical levels of territorial identity, which often is well-accentuated in post-socialist societies. Jansen, S. (2001) and Zechenter, K. (2015) suggested that the symbolic success of post-socialist cities depends on aligning the city's identity with the general prevalent understanding of national identity. However, there is evidence that in post-socialist countries local urban identity, due to some reason, may run counter to the national identity, as it happened in Sevastopol before the annexation of Crimea (Qualls, K.D. 2009) and in post-Milosevic Belgrade (Volcic, Z. 2005). The representations of four Ukrainian cities in fictional narratives by contemporary authors show underscored sense of belonging to the local territory, yet the sense of belonging to the nation and the world is not dismissed (Rewakowicz, M.G. 2010).

Urban space may be treated simultaneously as a mirror of existing urban identity and as a factor of its development. This statement is widely supported in literature (Karaman, A. 2001; Stobart, J. 2004; Baris, M.E. *et al.* 2009). Urban landscape, seen by people every day, shapes their representations about the city and simultaneously reflects both spontaneous and deliberately constructed changes in identity, making visible the interactions (including contestation) of different actors and stakeholders. The public attitudes to the certain changes in urban landscape often display hidden or low-observable aspects of local identity development. The transformation of meaning, together with the use and attitude toward landscape, has become visible due to spatial and functional manifestations of post-socialist cities (Czepczyński, M. and Sooväli-Sepping, H. 2016). Diener, A.C. and Hagen, J. (2013) argue that varied and often competing economic, cultural, and political forces are narrating the new national identity through urban space. This is especially true for historical urban space (Azaryahu, M. and Foote, K.E. 2008). Political elites are engaged in a symbolic dialogue with each other and with the public through both physical transformations and "commemorative maintenance" of monuments having high symbolic value (Forest, B. 2002; Burch, S. and Smith, D.J. 2007; Adams, J.S. 2008). According to Ter-Ghazaryan, D.K. (2013), the transformation of prominent places represents the vision of elites but simultaneously often receives a critical voice from the local residents. Moreover, the attempts to reconstruct important monuments of the past often can generate a contestation of the same past they are intended to cement (Aleksandravičius, E. 2006; Haskins, E.V. 2009). Simultaneously, the socioeconomic changes reflected in housing stock, structure of land use, etc. also contribute to changing urban identity (Bater, J.H. *et al.* 1998). However, we should take in mind that the landscape of post-socialist city often represents a mix of socialist urban fabric and capitalist forms fitted into it (Dingsdale, A. 1999), which exacerbates conflicts between related senses of place.

Numerous studies (Kavaratzis, M. and Ashworth, G.J. 2005; Insch, A. and Florek, M. 2010; Mohapatra, B. and Razak, A. 2013; Kavaratzis, M. and Hatch, M.J. 2013; Rius-Ulldemolins, J. and Jiménez, L.P. 2016; Agboola, O.P. 2017) point out that strong identity makes urban community more consolidated and resilient to internal and external challenges and helps to create an attractive

image of the city for tourists and investors. The stronger is local identity, the more actively residents participate in forming their surroundings, in maintaining the built cultural heritage and in negotiating the development of their city (Pap, A. 2014). This is specifically true for post-socialist cities in their search for own unique character in order to increase the competitiveness (Young, C. and Kaczmarek, S. 2008; Oktay, D. and Bala, H.A. 2015).

To extend our knowledge about the relationship between urban space and post-socialist identity formation, especially given the lack of relevant studies in post-Soviet space, we decided to have a closer look on the Ukrainian city having two essential characteristics. First, it should be typical and representative case in terms of historical heritage, industrial development, tourism potential, level of symbolical penetration of socialism into the urban landscape, etc. Second, it should have sufficiently intense pace of both post-socialist identity building and transformation of urban space. Having such a research subject, we focused on the following aspects:

1. Applicability of previously known post-socialist strategies and patterns of urban identity building in transition to the typical post-Soviet city.

2. Conflict between the new history-driven and globalization-driven elements of identity.

3. Relationships between local, national and supra-national identities in post-Soviet urban identity building.

Being convinced in the feasibility of a holistic approach to the study of urban identity (Oktay, D. and Bala, H.A. 2015), we performed pre-analysis of the urban environment of chosen case city followed by sociologic survey of the inhabitants.

City of Vinnytsia as a case

In this study we focused on the city of Vinnytsia, located in the south-western Ukraine on the banks of the Southern Bug River, administrative capital of the homonymic region, the largest city (373,000) within the historical region of Podolia, pretending to be its informal capital. Since the first mention in written sources (1363), it belonged to the Grand Duchy of Lithuania (until 1565), Polish-Lithuanian Commonwealth (1565–1792), Russian Empire (1792–1917), Ukrainian People's Republic (1917–1920), the Soviet Union (1920–1991), and independent Ukraine (since 1991). Such comprehensive history has determined heterogeneity of the urban landscape and historical memories that could be actualised in local identity.

Since the Soviet Union collapse, the city's economy experiences transition from industrial to post-industrial one, characterized by decline in traditional industry (first of all precision machinery) and burst in tertiary sector (predominantly retail, but also IT-sector and tourism). The current Strategy 2020 for the city development contains numerous emphases on the regional leadership of Vinnytsia in Podolia and all central Ukraine.

Since 2014, Vinnytsia turned into an economic and political domain of key current Ukrainian power holders. In particular, Volodymyr Groysman, Ukrainian Prime-Minister since 2016, was a Mayor of Vinnytsia between 2006 and 2014; he managed to implement a series of successful municipal reforms, which brought Vinnytsia to the top of Ukrainian urban ratings. In particular, it was twice (in 2013 and 2015) recognized as the best city for life in Ukraine. Petro Poroshenko, Ukrainian President since 2014, several times was elected a parliamentarian precisely in the local electoral constituency and has business interests in the city, including two Roshen confectionary factories. The Roshen Light-Musical Fountain, which started to give performances in 2011 and became the most famous local tourist attraction, was constructed at the expense of the Poroshenko's Charity Foundation.

Nowadays Vinnytsia, being one of the most economically affluent Ukrainian cities, experiences rapid changes of urban landscape, including renovation of historical architectural heritage, new housing construction; substitution of traditional markets and

pop-up retail with modern shopping malls, boom of street-art, as well as modern forms of urban greening and landscape design. However, aggressive commercialization often threatens the historical legacy of the city, causing numerous urban planning conflicts.

Vinnytsia is a city where different actors are making clearly expressed attempts to promote local urban identity. In the Soviet epoch, the city was associated primarily with two tourist attractions: the Werwolf, Hitler's headquarters, and the museum-estate of the prominent surgeon Nikolai Pirogov. The city was also known as "Small Kyiv" (for similar hilly terrain along the riverside) and "Capital of Sugar Donbas" (surrounding region was the main producer of sugar beet in the USSR). Since the 2000s, numerous attempts have been made to restore memory of those historical epochs that were consciously silenced in Soviet times. This is, first of all, so-called "Silver Age of Optimism", a period of rapid development of the city of the late 19th and early 20th centuries, when the ordinary district town quickly turned into a powerful regional centre. In particular, the last decade was marked by a mass campaign, started by local history experts and taken up by the city administration, popularizing the legacy of Hryhoriy Artynov, a chief city architect in 1900–1919, who had factually designed the architectural face of the modern city centre. Another actualized historical period was the Ukrainian struggle for the independence (1917–1922) when Vinnytsia twice (in February and March of 1919 and in May and June of 1920) was the temporary capital of the Ukrainian People's Republic. Also, the city is increasingly mentioned as an important military-administrative centre of the Cossack times. The memory and ideas of these historical epochs are widely used while celebrating the main annual city holidays – the City Day and the Europe Day. This appeal to the history is reflected in the urban landscape by means of renaming the streets, establishment of monuments, opening thematic museums, etc.

Methodology

The survey of inhabitants was conducted in April-May 2016 and embraced 168 respondents. Only local residents permanently living in the city at least for the last 5 years were eligible. The sample was representative in terms of sex and age structure. A questionnaire contained a set of questions targeted at respondents' opinion on the urban space transformation, as well as their ideas and representations about the city. The design of the questionnaire was based on the elaborations of Gospodini, A. 2004, Baris, M.E. *et al.* 2009, Saban Ökesli, D. and Gürçinar, Y. 2012, van der Lugt, R. 2013, Oktay, D. and Bala, H.A. 2015, as well as on the previous experience of the authors in studying urban identity. Also, we reckoned with some previous results (Melnychuk, A. *et al.* 2013) describing key challenges of the selected city transformation.

We used the following set of questions:

1. What are the symbols of your city? [open-ended; up to 3 options].

2. How does the urban space have changed? [open-ended].

3. How did the latest architectural and planning innovations change the face of the city? [4 answer options – see *Figure 1*].

4. What does the city need? [5 answer options – see *Figure 3*]

5. How appropriate do you consider the following transformations of urban landscape? [14 answer options – see *Figure 4*; the respondents had to rate each case using the following scale: +2 (very appropriate), +1 (quite appropriate), 0 (indifferent, has the right to exist), –1 (bad), –2 (unacceptable)].

6. What does the city means for you? [10 answer options – see *Figure 5*; the respondents had to set up priorities from the most (10 points) to the least (1 point) important].

7. What is your attitude to the statement that Vinnytsia is a provincial city? [5 answer options: A. Negative: Vinnytsia is really not quite a big city, but provincialism is measured rather by the way of thinking and living then the number of population; B. Positive: Vinnytsia

is a relatively quiet, cosy, compact city with good environmental conditions; C. Vinnytsia is quite a small but upcoming city, which, however, evolve to get rid of provincialism; D. Negative: Vinnytsia is a great progressive European city that cannot be called provincial; E. Positive: Vinnytsia is a grey and dirty city with a lack of opportunities but excessively high ambitions of local administration].

8. Who should be memorialized in the city (in the form of monuments, street names, etc.)? [5 answer options: A. prominent locals; B. prominent people related to Vinnytsia; C. prominent Ukrainians; D. fighters for freedom and independence of Ukraine; E. outstanding figures of the world history and culture].

9. How the following actors (neighbours, relatives and friends, local history experts, local authorities, NGOs) have influenced your attitude to the city in recent times? [3 answer options for each of the actors: A. positively; B. neutrally; C. negatively].

10. After the installation of Roshen light-musical fountain, Vinnytsia is: [2 answer options: A. city with a fountain; B. city near a fountain).

Ranges, medians and quartiles for questions with ranking and score evaluations were calculated using Statistica 9.0 analytics software package. The answers to the open-ended Question # 2 were processed to identify the main semantic ideas, which were visually represented using tag cloud technique.

Survey results and discussion

Respondents indicated 20 landmarks as urban symbols. The shortlist of 5 landmarks, mentioned by more than 10 per cent of respondents, includes 4 traditional symbols of the city belonging to different epochs (Tower of Vinnytsia – 73.5%; Pirogov Museum – 44.6%; Park Entrance Arch – 38.6%; Complex of monasteries and fortifications, known as "The Murals of Vinnytsia" – 14.5%) and only 1 modern symbol, Roshen Fountain (63.9%), which has rapidly burst into a cohort of leaders. We have not found any statistically significant effect of modern reconstruction and renovation: this indicates that a clear hierarchy of urban symbols has been shaped in the city, which is difficult to change, and only media-promoted megaprojects could interfere with it.

Respondents believe that urban space has become more modern and comfortable; the most of new facilities have harmoniously supplemented the historical environment. However, approximately every fourth respondent pointed at destruction of the city's historical face spoiling local urban spirit; there is no public consensus regarding the profoundness of urban space changes (*Figure 1*).

Respondents believe that the city experiences intensive changes consisting in construction, renewal and renovation. The general direction of these changes is considered to be positive and is defined through the terms of improvement, progress, development, and beautification. Citizens believe urban space to become better, which means primarily – more modern, more attractive, more comfortable, and more European. The most often mentioned objects of changes were: urban infrastructure (in the context of modernization), historic buildings and monuments (in the context of renovation), and public spaces (in the context of beautification and improvement) (*Figure 2*).

The respondents have quite a consensus opinion about the overload of urban space with such post-socialist innovations as shopping malls. Although the majority of respondents give the greatest importance to the creation of new industrial facilities, it is necessary to emphasise a very large range of estimates. Rehabilitation and restoration of historic buildings and architectural monuments was recognized to be the second most important priority. Not much less importance is attached to improvement of public spaces and landscaping: these options had strong public support despite the fact that over the last decade the city's authorities have already done a great job in these areas (*Figure 3*).

The greatest public support was observed for the restoration of historical areas, monuments and public spaces without drastic changes to their visual appearance and func-

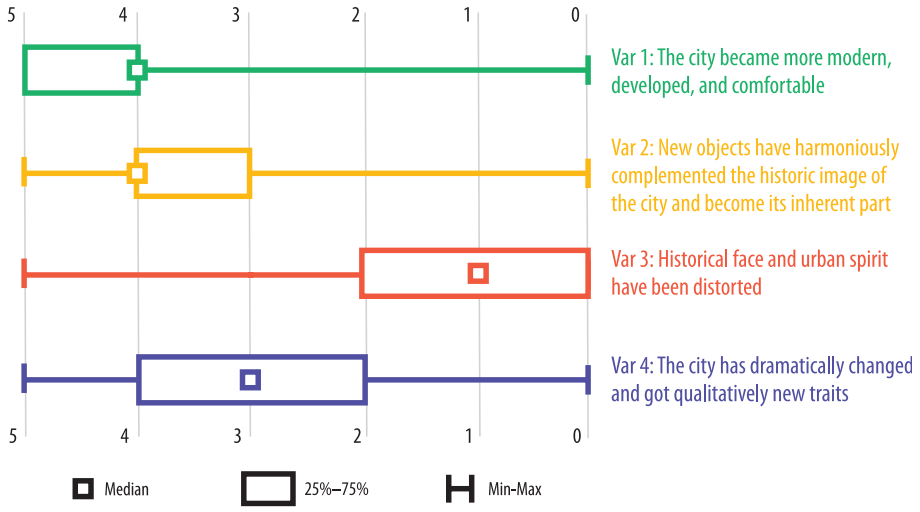

Fig. 1. How has the urban space changed?

Fig. 2. Wordclouds reflecting frequency of ideas mentioned by the respondents

tionality, when the old senses and connotations of place are strengthened or combined with new ones without obvious contradiction in between (*Figure 4*). On the other hand, changes leading to the destruction of the old senses and causing aesthetic and/or functional conflict with already shaped urban landscape received the most unfavourable evaluations. The first example of such a situation is construction of the Cloud shopping

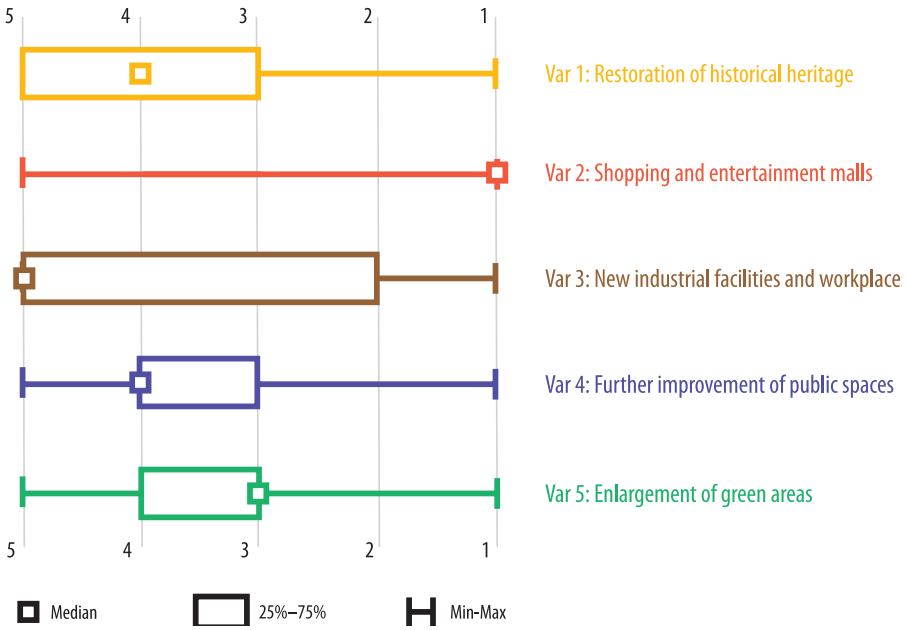

Fig. 3. What does Vinnytsia need?

mall in direct proximity to the Holy Virgin Cathedral, an architectural monument, dated back to 1745: two buildings are completely incompatible in terms of function and design. The second example is protracted reconstruction of the Gagarin Square that led to the total destruction of its previous appearance and made it similar to many other squares with underground shopping malls in different cities throughout the country. However, we should admit that respondents have general critical attitude to the construction of new shopping malls regardless of their harmonisation with the surrounding environment. Particularly comprehensive situation is observed when both old and new senses of place are historically legitimate and not imposed by administration or private business, but should compete with each other within the same place. Basically, this leads to a split of public opinion, as happened in the case of the Shevchenko monument at Teatralna Square. Since the beginning of the 20th century, this place was informally known as "The Paris of Vinnytsia" and nowadays is used as a place for jazz and rock festivals. Therefore, many citizens consider it incompatible with the figure of the Ukrainian canonical poet and artist. On the other hand, the square was a place where locals gathered during the Euromaidan, so the other part of respondents has strong assertion that Shevchenko as a national prophet and visionary of public unrest has every right to be memorialized there.

Changes, associated with the development of urban industrial base and infrastructure (e.g. construction of a new tram line), have relatively good public ratings. However, a negative effect caused by the links with political figures can be traced. In particular, construction of the second Roshen factory, linked to Poroshenko, received relatively poor assessments although it is a big employer, providing citizens with additional workplaces.

The public opinions on the city's provinciality were divided almost into halves: while 55 per cent of respondents believe that Vinnytsia is not a provincial city, the other 45 per cent

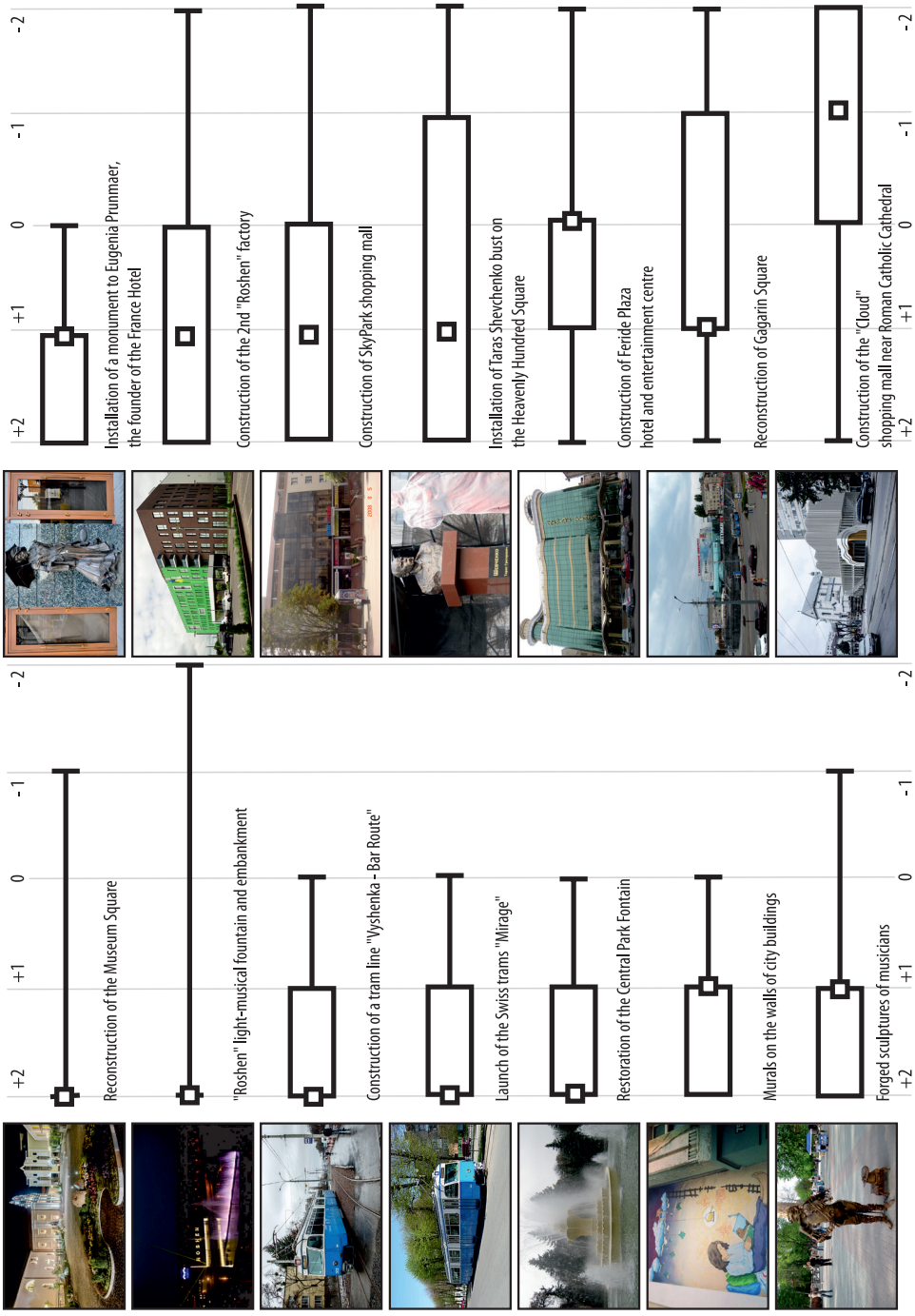

Fig. 4. Attitudes to the concrete transformations of the urban landscape

hold the opposite. However, more than 70 per cent of respondents believe provincialism to be negative value disrespecting the city and its residents. For the relative majority of respondents, provincialism is determined rather by local culture then the size and status of the city. Another large group of respondents believes provincialism to be advantage as it manifests itself through the calmness, quietness, compactness, and good environmental conditions. Every fifth resident believe the provinciality to be objective reality for Vinnytsia. However, nearly the same proportion of residents considers Vinnytsia to be a progressive and European city.

Regarding the priority of meanings and connotations, associated with the city, the following regularities are observed (*Figure 5*). First, senses reflecting local uniqueness ("City upon Bug River", "Place where Pirogov lived", "Kotsiubinsky Motherland") are more popular than those based on the similarity of Vinnytsia to other cities ("The Little Kyiv"). Second, it is important for the respondents to understand their city as advanced, leading and better over the others ("The best city in Ukraine", "The capital of Podolia"); on the contrary, connotations, referring to the relative inferiority of the city, including provinciality, have low priority ("The Little Kyiv", "The Golden Province"). Third, direct or indirect relationship with modern political or commercial figures has negative connotations: ideas of "Poroshenko's Motherland" and "Ukrainian Chocolate Capital" are clear outsiders.

Public opinions about preferences in commemoration are very symptomatic: more than 86 per cent of respondents think that commemorated people should have some relation to the city (including 31% of respondents take the view that these should be locals born in Vinnytsia). This obviously indicates a shift toward local identity and the desire to make the city's landscape unique and different from the urban landscapes of other cities, dropping with the Soviet practice, when every city had a similar set of street names and memorials commemorating people having nothing common with a local context. However, this shift does not mean neglect-

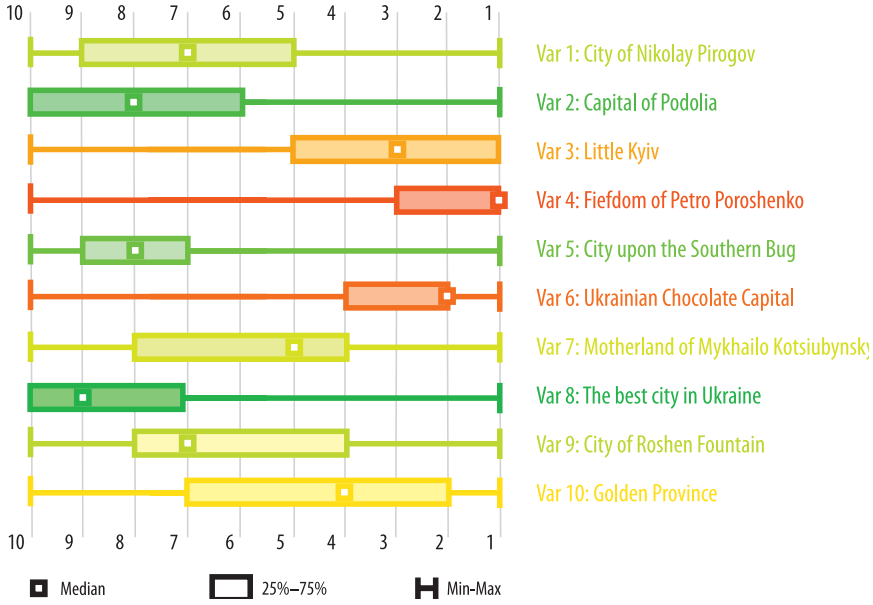

Fig. 5. Ranking of meanings and senses, associated with the city

ing of national identity, as 36 per cent of respondents expressed in favour of fighters for Ukrainian freedom and independence.

Activities of the local history experts and the local authorities have the most positive influence on the public attitudes to the city. Interestingly, NGOs have the worst balance of positive and negative influence. This suggests that, firstly, civil society in Vinnytsia remains in the shadow of the local administration, which leads the process and finally win the laurels of reformers, and secondly, public willingness to distance from politics relates rather to state power holders than the local city administration, whose activities are perceived in a positive light. Finally, absolute majority of respondents consider Vinnytsia as a city with a fountain, and only 2 per cent think that the city is only an addition to this modern sightseeing.

Similar to the previous studies in field (Oktay, D. 1998; Bornberg, R. 2008; Oktay, D. and Bala, H.A. 2015), the survey confirmed the importance of locally characteristic and identifiable natural landscape in shaping urban identity, as it represents one of the most stable major elements of identity and substantially contributes to the perceived quality of life. Simultaneously, new aesthetic of public spaces in the central part of the city, especially main squares, play special role in shaping new urban identity (Stober, D. and Cavrić, B. 2014) and, as Boros, L. *et al.* (2016) emphasizes, their transformation often is accompanied by acute urban conflicts due to confrontation of different interests, ideologies and urban policies. Like in other cases (Young, C. and Kaczmarek, S. 2008; Saban Ökesli, D. and Gürçinar, Y. 2012), the rediscovery, restoration and representation of the architectural heritage, as well as the regeneration of the cultural space, has been a key feature of post-socialist identity in Vinnytsia.

We can deem that in Vinnytsia, like in the other cities in Central and Eastern Europe, the identity transformation occurs under conditions of neo-liberalization, modernisation and globalisation, with specially pronounced role of so called "Europeanization", like it was in Leipzig (Coles, T. 2003), Krakow (Hughes, H. *et al.* 2003), Warsaw (Crowley, D. 2003), Lodz (Young, C. and Kaczmarek, S. 1999, 2008); Iași (Roșu, L. 2015). This "Europeanization" consists in promotion of European art, culture and values, including multiculturalism, by means of changing architectural appearance of the city and such public events as mass celebrations. The elements of the "unwanted socialist past" (see Young, C. and Kaczmarek, S. 2008) are preserved but obscured or, at least, not specially emphasised. There is also typical common reference to the idealized "Golden Age" of the city development, as in Warsaw (Czarniawska, B. 2002), Lodz (Young, C. and Kaczmarek, S. 1999, 2008), Leipzig (Coles, T. 2003), Mostar (Grodach, C. 2002), Novgorod (Petro, N.N. 2005), Banská Bystrica (Bitusikova, A. 1998), Tallinn (Hackmann, J. 2005), Odessa (Gubar, O. and Herlihy, P. 2005), etc.

Like in many other post-socialist cities, in our case study the modern identity at large pushes traditional industry to the back and relies on postindustrial image stressing the development of the service sector (including leisure, tourism, and art) and high-tech industries (Madsen, H. 1992; Wilkinson, S. 1992; Short, J.R. *et al.* 1993; Paddison, R. 1993; Noworol, A. 1997; Waskiewicz, J. and Bogacz, T. 1997; Young, C. and Lever, J. 1997; Grifiths, R. 1998). Nowadays, industry as such is no longer considered as evidence of the city's economic power and is not a reason for pride: now it has a subordinated position in the hierarchy of values and should not interfere with the realization of the main value – a high quality of life. However, the survey reflects certain reassessment of the industry and its importance for both urban identity and economy, which stands in line with suggestions that some identity elements may resists forgetting, although are officially disregarded (Adler, N. 2005; Young, C. and Kaczmarek, S. 2008).

Our study supports the conclusions of Saban Ökesli, D. and Gürçinar, Y. (2012) that high consciousness about the history and identity of the city really contributes to the high quality of the urban environment. Since

modern identity building in Vinnytsia is drastically based on the senses associated with the historical urban architecture, residents of Vinnytsia reckon the aggressive commercialization as the main threat to the integrity of the historical urban landscape and, accordingly, urban identity. This is probably an additional reason why new facilities for leisure and entertainment, like shopping malls, at the moment have not received important symbolical value, although they have substantially changed the visual appearance of the city and altered the way of public entertainment, which is similar to the findings from other national urban contexts (e.g. Baris, M.E. *et al.* 2009). Simultaneously, since the idea of development and progress has become one of the fundamentals of the new urban identity, constant new construction is perceived as a necessary condition for the existence of the city. It gives the administration and business the opportunity to manipulate with public opinion in the implementation of their own projects, appealing to meet this request for constant development. However, as we see from the attitudes to the concept of provinciality, the pathos of modernization, intrinsic for some part of population, is balanced by the aspirations of another part to preserve the existing urban landscape. The overwhelming majority of inhabitants appreciate much the status of the city as a developed and perspective, but everyone understands this progress in its own way; however, the priority is the development of local urban culture and the preservation of the optimal size of the city to ensure a high quality of life.

The specific role of Vinnytsia as a domain of current Ukrainian chief power holders, as well as successful reforms implemented in the city, have affected the local urban identity in a dual fashion. On the one hand, citizens of Vinnytsia have developed a kind of superiority over the others, as they have had been continuously taught that their city is better, more progressive and more successful than others, and now it is important for them to keep the same feeling (Krylov, M.P. 2010). Also, the city pretends to be a regional leader, trying to enter a cohort of a top of influential Ukrainian cities. Simultaneously, this attitude to the city is not automatically transferred to the locally originated politicians; on the contrary, we see a steady desire to distance from them as well as from the associated changes in the urban landscape.

Conclusions

Modern urban identity in Vinnytsia has significantly transformed during post-Soviet period. Nowadays it is gradually shaping of many patches, representing different periods of urban history and constituting together a comprehensive mosaic (including senses associated with the Soviet era that recede into the background but do not completely disappear). This gives grounds for talking about the inclusive model of urban identity formation. At the same time, the list of main urban symbols and representations about the city remains relatively constant, indicating a stable core of identity, which is based around basic things such as the city's location in the historic region, key local physiographic and cultural landmarks, brand personalities, etc. This core of identity is inertial and requires a great deal of effort (e.g. long popularization campaign via the media) to be changed.

We confirmed our hypothesis that identity-related discussions in Vinnytsia are centred on the issues of leadership, Europeanization and modernization. Current situation, when the city is appreciated for "been better than the others", creates certain risks in the future due to the reduced resilience of the urban community to possible serious challenges, as the state of constant prosperity and leadership cannot last forever. Therefore, if a city finds itself in a difficult economic situation and loses informal state support, the public euphoria may quickly disappear, which may in turn cause negative social and economic processes. However, the issue of modernization, including aggressive commercialization within the historical areas, is the most crucial and splitting public opinion right now. On

the one hand, modernization of urban space receives public approvals, since it is consistent with the idea of progress; on the other, it destroys the uniqueness of urban space as a basis for traditional urban identity.

The survey confirmed that industry is not any more considered as an essential element of urban identity, although is still treated as an important component of the local economy. Inhabitants feel a strong need in comfortable urban environment rather than in political/ideological symbols, they seek for human-friendly, aesthetic, safe, both morphologically and functionally diversified urban space, providing high quality of life for the locals and attractiveness for the tourists. Also, we observe pronounced shift to the local and regional values, although the connection with the national identity remains important.

Thus, local identity may be considered as one of the key factors determining the perception of the urban space transformation. This suggests that developed identity makes urban landscape more resilient to the possible aggressive changes. The success of identity transformation is largely defined by the possibility to painlessly combine new senses of place with the already existing. The public assessment of urban space transformation is also affected by coverage by local media, intensity and consistency of communication between urban administration, local cultural elites, public activists and the ordinary citizens, as well as by the moral and ethical assessment of the individuals involved in the particular transformation.

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REFERENCES

Adams, J.S. 2008. Monumentality in urban design: The case of Russia. *Eurasian Geography and Economics* 49. (3): 280–303.

Adler, N. 2005. The future of the Soviet past remains unpredictable: the resurrection of Stalinist symbols amidst the exhumation of mass graves. *Europe - Asia Studies* 57. 1093–1119.

Agboola, O.P. 2017. The influence of open space utilization on residents' attachment with community: A case study of rural market square in southwest Nigeria. *Archnet-IJAR* 11. (1): 44–66.

Aleksandravičius, E. 2006. Post-communist transition: The case of two Lithuanian capital cities. *International Review of Sociology* 16. (2): 347–360.

Azaryahu, M. and Foote, K.E. 2008. Historical space as narrative medium: On the configuration of spatial narratives of time at historical sites. *GeoJournal* 73. (3): 179–194.

Baris, M.E., Uckac, L. and Uslu, A. 2009. Exploring public perception of urban identity: The case of Ankara, Turkey. *African Journal of Agricultural Research* 4. (8): 724–735.

Bater, J.H., Amelin, V.N. and Degtyarev, A.A. 1998. Market reform and the central city: Moscow revisited. *Post-Soviet Geography and Economics* 39. (1): 1–18.

Bitusikova, A. 1998. Transformations of a city centre in the light of ideologies: the case of Banská Bystrica, Slovakia. *International Journal of Urban and Regional Research* 22. 614–22.

Bornberg, R. 2008. Identity by spatial design. *Urban Design International* 13. 182–200.

Boros, L., Fabula, Sz., Horváth, D. and Kovács, Z. 2016. Urban diversity and the production of public space in Budapest. *Hungarian Geographical Bulletin* 65. (3): 209–224.

Burch, S. and Smith, D.J. 2007. Empty spaces and the value of symbols: Estonia's 'war of monuments' from another angle. *Europe - Asia Studies* 59. (6): 913–936.

Coles, T. 2003. Urban tourism, place promotion and economic restructuring: the case of post-socialist Leipzig. *Tourism Geographies* 5. 190–219.

Crowley, D. 2003. *Warsaw*. London, Reaktion Books.

Czarniawska, B. 2002. Remembering while forgetting: the role of automorphism in city management in Warsaw. *Public Administration Review* 62. 163–173.

Czepczyński, M. and Sooväli-Sepping, H. 2006. From sacrum to profanum: reinterpretation of communist places of power in Baltic cities. *Journal of Baltic Studies* 47. (2): 239–255.

Diener, A.C. and Hagen, J. 2013. From socialist to post-socialist cities: Narrating the nation through urban space. *Nationalities Papers* 41. (4): 487–514.

Dingsdale, A. 1999. Budapest's built environment in transition. *GeoJournal* 49. (1): 63–78.

Forest, B. 2002. Unraveling the threads of history: Soviet-era monuments and post-Soviet national identity in Moscow. *Annals of the Association of American Geographers* 92. (3): 524–547.

Gospodini, A. 2004. Urban morphology and place identity in European cities: built heritage and innovative design. *Journal of Urban Design* 9. 225–248.

Griffiths, R. 1998. Making sameness: place marketing and the new urban entrepreneurialism. In *Cities, economic competition and urban policy.* Ed.: Oatley, N., London, Chapman, 41–57.

Grodach, C. 2002. Reconstituting identity and history in post-war Mostar, Bosnia-Herzegovina. *City* 6. 61–82.

Gubar, O. and Herlihy, P. 2005. *The persuasive power of the Odessa myth*. Paper presented at the conference 'Cities after the Fall: European Integration and Urban History' (Mar.), Harvard University, USA. Available at: http://www.fas.harvard.edu/~ces-lib/docs

Hackmann, J. 2005. *Post-communist Tallinn: great architecture for a small nation.* Paper presented at the conference 'Cities after the Fall: European Integration and Urban History' (Mar.), Harvard University, USA. Available at: http://www.fas.harvard.edu/~ces-lib/docs

Haskins, E.V. 2009. Russia's post-communist past: the cathedral of Christ the Savior and the reimagining of national identity. *History and Memory* 21. (1): 25–62.

Hein, C. 2012. Spaces of identity in East European cities. *Journal of Urban History* 38. (2): 372–378.

Hughes, H., Allen, D. and Wasik, D. 2003. European capital of culture and its significance for tourism and culture: the case of Krakow 2000. *International Journal of Arts Management* 5. 12–23.

Insch, A. and Florek, M. 2010. Place satisfaction of city residents: findings and implications for city branding. In *Towards Effective Place Brand Management: Branding European Cities and Regions*. Eds.: Ashworth, G. and Kavaratzis, M., Cheltenham, Edward Elgar Publishing, 191–204.

Jansen, S. 2001. The streets of Beograd. Urban space and protest identities in Serbia. *Political Geography* 20. (1): 35–55.

Karaman, A. 2001. Defining the regional identity: conceptual parameter of urban morphology. *Journal of Research in Architecture & Planning* 1. 70–88.

Kavaratzis, M. and Ashworth, G.J. 2005. City branding: an effective assertion of identity or a transitory marketing trick? *Tijdschrift voor Economische en Sociale Geografie* 96. (5): 506–514.

Kavaratzis, M. and Hatch, M.J. 2013. The dynamics of place brands: an identity-based approach to place branding theory. *Marketing Theory* 13. (1): 69–86.

Krylov, M.P. 2010. *Regional identity of the European Russia population*. Moscow, Novyi Khronograf. (in Russian)

Madsen, H. 1992. Place marketing in Liverpool: a review. *International Journal of Urban and Regional Research* 16. 633–640.

McNeill, D. and Tewdwr-Jones, M. 2002. Architecture, banal nationalism and re-territorialization. *International Journal of Urban and Regional Research* 27. 738–743.

Melnychuk, A., Gnatiuk, O. and Rastvorova, M. 2013. Territorial identity of the population of Ukraine: impact on spatial transformations. *Kyiv Geographic Almanac* 8. 170–175.

Mohapatra, B. and Razak, A. 2013. Place attachment and participation in management of neighbourhood green space: a place-based community management. *International Journal of Sustainable Society* 5. (3): 266–283.

Molnár, V. 2013. *Building the State. Architecture, Politics, and State Formation in Post-War Central Europe.* London, Routledge.

Noworol, A. 1997. Strategią rozwoju Krakowa (Krakow development strategy). In *Marketing Teritorialny. Strategia wyzwania dla miast i regionov*. Ed.: Dornanski, T., Łódź, University of Lodz, 132–138.

Oktay, D. 1998. Urban spatial patterns and local identity: evaluations in a cypriot town. *Open House International* 23. (3): 17–23.

Oktay, D. and Bala, H.A. 2015. A holistic research approach to measuring urban identity: findings from Girne (Kyrenia) area study. *Archnet-IJAR* 9. (2): 201–215.

Paddison, R. 1993. City marketing, image reconstruction and urban regeneration. *Urban Studies* 30. 339–350.

Pap, Á. 2014. *The relationship between the built cultural heritage and the local identity – actor-centred geographical analysis based on Budapest case studies.* Theses of the PhD dissertation. Szeged, University of Szeged.

Petro, N.N. 2005. *Old Russia's new city: Novgorod the great as a political model*. Paper presented at the conference 'Cities after the Fall: European Integration and Urban History' (Mar.), Harvard University, USA. Available at: http://www.fas.harvard.edu/~ces-lib/docs

Qualls, K.D. 2009. Today's travel through Sevastopol's past: post-communist continuity in a 'Ukrainian' cityscape. In *The Cities after Fall of Communism: Reshaping Cultural Landscapes and European Identity*. Ed.: Czaplicka, J., Gelazis, N. and Ruble, B.A., Washington DC, Woodrow Wilson Center Press, 167–193.

Rewakowicz, M.G. 2010. Geography matters: Regionalism and identities in contemporary Ukrainian prose. *Canadian-American Slavic Studies* 44. (1–2): 82–101.

Rius-Ulldemolins, J. and Jiménez, L.P. 2016. Cultura, transformación urbana y empoderamiento ciudadano frente a la gentrificación: Comparación entre el caso de Getsemaní (Cartagena de Indias) y el Raval (Barcelona). (Culture, urban transformation and civic empowerment in front of gentrification: comparison of the cases of Getsemani [Cartagena de Indias] and el Raval [Barcelona]). *EURE (Santiago)* 42. (126): 97–122.

Roșu, L. 2015. The urban transformations of a post-socialist city centre. The socialist relicts and current identity of Iași historical city centre. *Lucrările Seminarului Geografic 'Dimitrie Cantemir'* 40. (1): 159–170.

Saban Ökesli, D. and Gürçinar, Y. 2012. An investigation of urban image and identity. Findings from Adana. *Ç.Ü. Sosyal Bilimler Enstitüsü Dergisi* 21. (1): 37–52.

Semian, M. and Nováček, A. 2017. The reinterpretation of histories in identities of newly established regions: The case of Local Action Groups in Czechia. *Hungarian Geographical Bulletin* 66. (4): 307–319.

Short, J.R., Benton, M., Buce, W.V. and Walton, J. 1993. Reconstructing the image of industrial city. *Annals of Association of American Geographers* 88. 207–224.

Stobart, J. 2004. Building and urban identity. Cultural space and civic boosterism in a 'new' industrial town: Burslem. *Social History* 29. 1761–1911.

Stober, D. and Cavrić, B. 2014. Dynamics and aesthetics of urban change in post-socialist Osijek, Croatia. *International Journal of Contemporary Architecture "The New ARCH"* 1. (2): 84–92.

Sýkora, L. 2009. Post-socialist cities. In *International Encyclopedia of Human Geography*. Ed.: Kitchin, R. and Thrift, N., Oxford, Elsevier, 387–395.

Ter-Ghazaryan, D.K. 2013. "Civilizing the city center": Symbolic spaces and narratives of the nation in Yerevan's post-Soviet landscape. *Nationalities Papers* 41. (4): 570–589.

van der Lugt, R. 2013. *Is the fostering of an urban identity through a city's past becoming history?* Master Thesis in Human Geography. Nijmegen, Radboud University Nijmegen.

Volcic, Z. 2005. Belgrade vs. Serbia: spatial reconfigurations of belonging. *Journal of Ethnic and Migration Studies* 31. 639–658.

Waskiewicz, J. and Bogacz, T. 1997. Strategią rozwoju miasta Wrocławia – zalozenia, cele, programy realizacyjne (Wroclaw city development strategy – grounds, tasks and programs to realize). In *Marketing Teritorialny. Strategia wyzwania dla miast i regionov*. Ed.: Dornanski, T., Łódź, University of Lodz, 139–145.

Wilkinson, S. 1992. Towards a new city? A case study of image-improvement initiatives in Newcastle upon Tyne. In *Rebuilding the City: Property Led Urban Regeneration*. Ed.: Healey, P., Davoudi, S. and O'Toole, M., London, E & FN Spon, 174–192.

Young, C. and Kaczmarek, S. 1999. Changing the perception of the post-socialist city: place promotion and imagery in Łódź, Poland. *Geographical Journal* 165. (2): 183–191.

Young, C. and Kaczmarek, S. 2008. The socialist past and post-socialist urban identity in Central and Eastern Europe. The case of Łódź, Poland. *European Urban and Regional Studies* 15. (1): 53–70.

Young, C. and Lever, J. 1997. Place promotion, economic location and consumption of the city image. *Tijdschrift voor Economische en Sociale Geografie* 88. 332–341.

Young, C. and Light, D. 2001. Place, national identity and post-socialist transformations: an introduction. *Political Geography* 20. (8): 941–955.

Zechenter, K. 2015. The repositioning of post-socialist narratives of Nowa Huta and Dunaújváros. *Revue des Études Slaves* 86. (1–2): 141–156.

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Euromaidan and conflict in Eastern Ukraine in social networking sites: Territorial differences of pro-Russian subscriptions in Ukraine

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Abstract

Securitization of cyberspace is of great geopolitical concern. Behaviour on the Internet is not diminishing the influence of existing borders but can polarize society along territorial divisions. The paper explores territorial differences in the subscription to public pages and open groups in social networking sites (SNS), which emerged as a reaction to revolutionary events in Ukraine (known as Euromaidan or Revolution of Dignity) in 2013–2014 and Russia-backed armed conflict in the East of the country. The findings show differences in subscription to such pages in Vkontakte (the most popular SNS in Ukraine before a ban in 2017) among citizens of Ukraine and Russia, regional centres in Ukraine, cities in uncontrolled by Ukrainian government territories, reclaimed by Ukrainian army territories, territories of Lugansk and Donetsk regions which were not under substantial control of Russia-backed separatists, and peripherial cities of the neighbouring Kharkiv, Dnipropetrovsk, and Zaporizhya oblasts. The paper also analyzes the geopolitical narratives of pro-Russian public pages in Vkontakte and shows how SNS could be used as a geopolitical tool.

Keywords: securitization of cyberspace, Euromaidan, conflict in Eastern Ukraine, social networking sites

Introduction

Social networking sites (SNS) are new battlefields of different political beliefs and preferences, geopolitical narratives and imaginations, attitudes towards conflicts and political and social contradictions. In Ukraine, the revolutionary events of 2013–2014 (known as Euromaidan or Revolution of Dignity) and armed conflict in Donbas resulted in many new public pages and groups in Vkontakte, Facebook, Odnoklasniki, and Twitter. Despite the opportunity to get a variety of information sources and directly communicate with opposing side of the conflict, which might have mediation and democratization effects, the practices of using SNS resulted in polarization of the society and formation of more profound cleavages. Public pages and open groups, which were covering events on the Maidan in Kyiv during the Revolution and later Russia-backed armed conflict in Donbas, were producing not only news reports. They started to propose a broader vision of the conflict, geopolitical narratives about enemies and friends (the US and NATO, European Union, Russia), new division lines between "Us" and "Them", legitimating and delegitimating narratives about political centres (Kyiv and Moscow) and relations to them, and geopolitical picture of the world. Moreover, Russian Federation involvement in the conflict was also supported by active information campaigns in SNS discrediting Ukraine as an independent state, de-legitimating new Ukrainian government, and promoting separatist movements within the country. It resulted in a ban of Russian SNS (Vkontakte and Odnoklasniki) in Ukraine as well as many other Russian websites in 2017.

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The use of SNS as a geopolitical tool often results in polarization of the society and raises a question about securitization of cyberspace. Such polarization has its territorial dimension. The intensity of the conflict in Ukraine strengthened not a nation-wide network of connections in SNS but regional (Duvanova, D. *et al.* 2016). The paper focuses on the manifestation of Ukrainian Revolution of 2014 and armed conflict in Donbass in SNS and aims to reveal territorial differences in the spreading of Russian geopolitical narratives and pro-Russian position in the conflict as well as differences between social networks in the representation of the events. In the first part, it shows the current state of research on political behaviour in SNS. The second part presents the methodology and data of the study. The third and fourth parts analyze territorial differences of choosing information sources in SNS in Ukraine, and the fifth part is dedicated to the content analysis of geopolitical narratives by pro-Russian public pages in Vkontakte.

Political behaviour in social networking sites

The use of the Internet brings new challenges to political geography research. Friedman, Th.L. (2005) states that in such conditions space is concerning place, which could be understood as making places obsolete and erasing territorial differences in political and social phenomena. However, Goldenberg, J. and Levy, M. (2009) empirical study suggests that new technologies are not undermining the uniqueness of places and influence of distance but even could emphasize them. Moreover, seemingly uncontrolled communications on the Internet are of geopolitical concern (Pinkerton, A. *et al*. 2011). One of the cases of this absence of control is the inability of nation-states to control the flow of information within their borders (especially in conflict situations). However, the ban of Russian websites and Vkontakte and Odnoklasniki SNS in Ukraine in 2017 is an example of how state government could impose control over the information space of the country. The paper argues for the examination of these "emergent arenas of securitization" (Bernazzoli, R.M. and Flint, C. 2009). Moreover, SNS are increasing their role in "popular production of geopolitical knowledge" (Pinkerton, A. and Benwell, M. 2014), which should be reflected in political geography studies.

On the one hand, SNS open access for the broader population to the same sources of geopolitical narratives (passing existing territorial borders) and contribute to bottom-up participation in their shaping. On the other hand, geopolitical actors receive a powerful instrument to spread their geopolitical imaginations and frame social and political issues in their interest. In such a case, political beliefs and geopolitical imaginations of particular places can be shaped by the politics of interested geopolitical actors – still, the question what territories are more vulnerable to such influences and why remains open.

Current research on political issues in SNS is focused on active use of them in electoral campaigns in different countries of the world (Kasmani, M.F. *et al.* 2014; Kruikemeier, S. 2014; Steenkamp, M. and Hyde-Clarke, N. 2014; Frame, A. and Brachotte, G. 2015), political mobilization of population for the action and participation in politics (Nam, T. 2012; Park, Ch.S. 2013), and correlation between online membership and offline engagement (Conroy, M. *et al.* 2012). However, it is essential that not only SNS change political behaviour but also places shape people's behaviour on the Internet and the use of social networking sites (Wang, D.M. *et al.* 2016). For instance, existing empirical studies reveal that Twitter networks are dependent on the geographical distance between users (Takhteyev, Yu. *et al.* 2012) and SNS users cluster themselves in politically homogeneous networks (Borondo, J. *et al.* 2014). Jackson, L. and Valentine, G. (2014) assume that such computer-mediated communication is a new way of doing politics through its absence and presence at the same time. Therefore, SNS are a new political and geo-

political instrument of influence, and, at the same time, their use is framed by the existing territorial differences.

We suggest that SNS not only work as registration of reality but also produce it and are a form of symbolical violence as Bourdieu, P. (1998) stated about television. Lippmann, W. (2017) suggests that social media influence on public opinion has two crucial aspects: (1) filtration of reality, and (2) focus of attention on prepared facts, which are understood as worked out by political actors, media, opinion leaders and other subjects engaged in and interested to influence public opinion. In case of public pages and open groups in SNS that emerged as a reaction to revolutionary events in Ukraine in 2013–2014, they were not only focused on prepared facts but also produced fake news and manipulated information for the sake of one side of the conflict. Consequently, SNS did not bridge political divides in Ukrainian society but polarize them further during the conflict (Duvanova, D. *et al.* 2015).

Social media and social networking sites also became part of soft power and public democracy strategies by geopolitical powers (Simons, G. 2015). As a seemingly uncontrolled channel of information, SNS became essential tools in the formation of alternative geopolitical narratives of conflicts, geographical imaginations about particular places and regions and their relations to political centres, a geopolitical picture of the world and relations between countries. Social media operations are an essential part of Russian propaganda in Eastern Europe (Helmus, T.C. *et al.* 2018). Russia was using social networking sites in Ukraine to frame its geopolitical messages (Gaufman, E. 2015). Historical myths, regional identity, and images of the enemy were exploited by the Russian Federation in spring 2014 in the Donbas region to escalate conflict (Osipian, Al.L. 2015). Therefore, territorial differences of the use of SNS in Ukraine during 2013–2014 revolutionary events and later during the armed conflict in Donbas are not only caused by internal factors and known regional differences in political preferences and voting behaviour in Ukraine (Liber, G.O. 1998; Birch, S. 2000; O'Loughlin, J. 2001; Barrington, L.W. and Herron, E.S. 2004; Clem, R.S. and Craumer, P.R. 2008; Osipian, Ar.L. and Osipian, Al.L. 2012; Peisakhin, L. 2013; O'Loughlin, J. *et al.* 2016), but also external involvement and mobilization of the population of Ukraine to reach geopolitical goals. Therefore, the paper is mainly focused on Russian SNS, subscription to pro-Russian public pages, and geopolitical narratives produced by them to examine territorial differences of the consumption of that content.

Data and methodology

Data was collected using publicly available information in Vkontakte, Facebook, Odnoklasniki, and Twitter SNS. Using search option for these SNS we found the number of public pages and groups, which have used such words as "Euromaidan", "Antimaidan", "Ukrainian Revolution", "Novorossiya", and "ATO" (Anti-terrorist operation) in their names, which shows their dedication to the revolution in Ukraine in 2013–2014 and armed conflict in Donbass. A number of subscribers/members was also received from publicly available information in search engines. Vkontakte was chosen as a case study for territorial differences in choosing information sources because it was the most popular SNS among Ukrainians in 2015 (11.8 million of individual user profiles in 2015 according to Gemius) and most politicized and polarized according to our preliminary study.

Vkontakte has a built-in instrument of filters, which gives the opportunity to filter subscribers of chosen public page or group by location, age, education, gender, image status, and other parameters filled in personal account settings. Some of the parameters are filled in the process of registration (hometown, age, and gender); therefore, all profiles have that information. It is important that location in Vkontakte is not presented as the user's current place of living but as a

hometown, which is a matter of choice by the user itself. Vkontakte has security settings, where the user can make information unavailable for the public. However, hometown and gender are open for filter instrument. For the purposes of this paper, information about the number of subscribers to top-5 ideologically opposite public pages and groups was collected for Ukraine and Russia in general, administrative centres of Ukrainian oblasts (regions), and for the case study cities in the conflict territories and neighbouring regions in Eastern Ukraine.

Vkontakte search instrument also allows filtering profiles by hometown. This feature was used for the second part of the study, which focuses on the conflict territories and neighbouring regions in Eastern Ukraine. For the research purposes we identified four different areas in the Eastern Ukraine: (1) uncontrolled by Ukrainian government, (2) reclaimed by military actions after occupation, (3) territories of Donetsk and Lugansk oblasts, which were not under substantial control of Russia-backed separatists, (4) periphery of the conflict zone in the neighbouring regions. For each of these areas we chose two (in case of neighbouring regions three because three oblasts are neighbouring Donetsk and Lugansk oblasts) comparable cities. For each of them, we used systematic sampling with gender quota. In the search window filtered by location, each randomly defined n-profile from general sample k was chosen to reach the quota of 25 male and 25 female profiles. Data about gender composition of the Internet audience of the chosen cities was unavailable; as a result, the equal number of males and females was chosen, which we should admit slightly differs from the actual composition of the population of the cities.

Consequently, in nine cities sample of 450 profiles was selected for the analysis of the behaviour in SNS: posts and reposts of political content, subscription to public pages with political content, membership in groups dedicated to political issues. Political issues were narrowed down to the Euromaidan revolution, the annexation of Crimea, and conflict in Donbass. Due to personal security settings, not all information was publicly accessible. Subscription to public page information was available for all the profiles, while information about membership in groups and posts and repost was limited only to those profiles, which did not make that information private. Our study revealed that in 30.4 per cent of cases (134 out of 450) people make the list of the groups they are members unavailable for the public.

The third part of the research was based on the data from two of the five most popular Antimaidan, pro-Russian, and pro-separatist public pages and groups: "Antimaidan" and "Russkie online – Novorossiya". The first one appeared as opposition to the revolutionary events in Ukraine in 2013–2014 and the second one as a promotion and support for the separatist movement in South-Eastern Ukraine. 1053 news posts from "Antimaidan" and 756 posts from "Russkie online – Novorossiya" were chosen for the content analysis. These posts include all, which were made on these pages in Vkontakte from March 10 to March 25, 2015, following a military escalation in January, Second Minsk Agreements in February, and the start of the positional armed confrontation. The content of all posts was coded into four groups: (1) about Ukraine, (2) in relation to Russia, (3) about the US and EU, and (4) Other. It was also decided to include armed conflict news posts as a category in the group "in relation to Russia" because they were done from the Russian perspective and often addressed the Russian government. Within these four groups, messages and framing of political events was coded into subgroups, which are presented and discussed in the last part of the paper.

We are aware of the limitations of the paper. It is focused only on the sources of the information people chose in Vkontakte during Euromaidan and conflict in the East of the country, which in some cases might not represent that people share geopolitical narratives and political beliefs of those public pages and open groups. However, the share of subscription to ideologically oppo-

site public pages in the total subscription to sources of information about Euromaidan and conflict reveals biased predominance or overweight of subscription to one of the sides of the conflict in particular areas. The paper has no examination of public pages, which had balanced position covering conflict events because it was one of the effects of SNS – emerged public pages and groups were emphasizing differences and not building bridges. Moreover, the data was collected after the period of the escalation of the conflict in February 2015, which should be taken into consideration interpreting the results of the study. The focus of the paper is on pro-Russian public pages and their geopolitical narratives because Russia is increasing its geopolitical presence in the world using SNS as geopolitical tools. The paper uses a concept of territorial differences, and we are cautious that obtained data is for particular cities.

Territorial differences in support of the Euromaidan Revolution in Ukraine in SNS

In November 2013, president of Ukraine, Viktor Yanukovych, refused to sign the Association Agreement with the EU during Eastern Partnership Summit in Vilnius despite public pressure in Ukraine. It caused protests and polarization of society. Subsequent events show the fundamental foreign policy cleavage in Ukraine, which supports Lijphart, A. (see Johnston, R.J. *et al.* 1990) complementation of the classical Lipset, S.M. and Rokkan, S. (1967) model. Two main social movements emerged as a reaction to the events in Vilnius and Kyiv: Ukrainian revolution (Euromaidan or Revolution of Dignity) and Antimaidan. In the course of events, the annexation of Crimea and Russia-backed armed conflict in Donbass resulted in the additional line of confrontation in society: pro-Ukrainian support of sovereignty versus the pro-Russian support of separatists, Novorossiya concept, and unity with Russia. However, in Ukraine, foreign policy cleavage is complicated by active Russian involvement.

The manifestation of the "Euromaidan" revolution and war in Donbass in SNS

As the Euromaidan and Antimaidan movements started in 2013, they were actively discussed in social networking sites. Figure 1 shows that thousands of public pages and groups emerged to report news and opinions on the ongoing conflict. Public opinion was divided into two camps: (1) supporters of the Euromaidan, and (2) opponents. SNS also followed that line of divide and pages where information was presented only from one of the points of view were created and actively promoted. Russian propaganda was also actively engaged in the process. For instance, two Russian social networking sites, Vkontakte and Odnoklasniki, were platforms were most of the pages criticizing Ukrainian pursuit for European integration and later supporting separatist movements and annexation of Crimea emerged. At the same time, only Odnoklasniki is dramatically one-sided in the number of pages and subscribers for Antimaidan and pages supporting separatism and unity with Russia.

Facebook is in the opposite pole, with most of the popular pages and their subscribers being pro-Ukrainian and pro-European in the coverage of the conflict. Twitter is less popular in Ukraine and had a balanced number of pro-Russian and pro-Ukrainian pages. Numbers show that despite many channels of information created to spread the pro-Russian view of the conflict; they were not so popular. Vkontakte is the most polarized SNS among analyzed. Top-5 public pages with pro-European and pro-Ukrainian stances have near two million subscribers and members, while top-5 pro-Russian pages have one million and a half. Vkontakte also was the most popular SNS in Ukraine and the most representative of the the Ukrainian internet audience in 2013-2017. In 2017, Vkontakte, as well as Odnoklasniki and many other Russian media, were banned in Ukraine as a part of the measures to counteract Russian aggression and propaganda *(Figure 1.* and *2).*

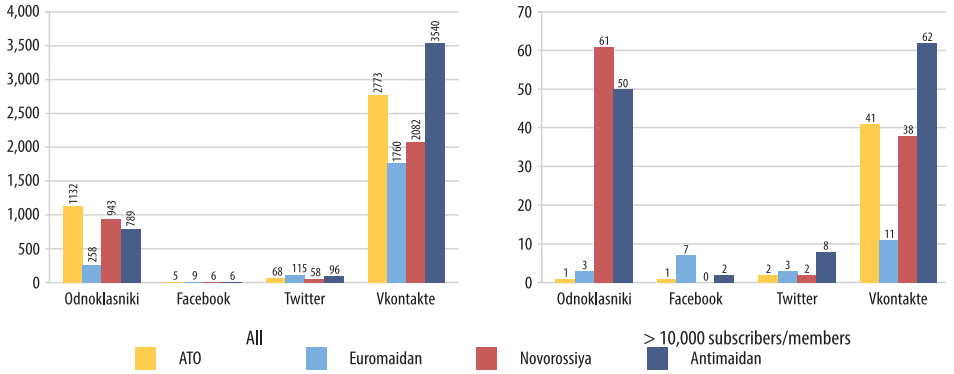

Fig. 1. Number of groups and public pages in popular social networking sites dedicated to the Ukrainian revolution of 2013–2014 and war in Donbass by keywords used in the name.

Moreover, the politicization of the citizens of the Russian Federation and their engagement in an online confrontation over the Euromaidan, lately annexation of Crimea and war in Eastern Ukraine are vivid. All the top-5 pro-Russian, Antimaidan, and pro-separatist pages and groups have the majority of subscribers from Russia, not from Ukraine *(Figure 3)*. At the same time, top-5 pro-Ukrainian sources of information in Vkontakte have 99 per cent and more subscribers from Ukraine. Therefore, the conflict manifestation in Vkontakte shows that it was not only within Ukraine but had a clear Russian involvement.

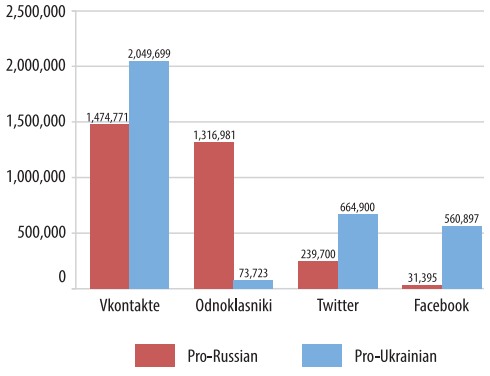

Fig. 2. Number of subscribers and members of top-5 ideologically opposite public pages in popular social networking sites in Ukraine, 19 February 2015.

Territorial differences of subscription to ideologically opposite public pages and groups in Vkontakte

Until Vkontakte was banned in Ukraine in 2017, it was the most popular SNS. It is the most representative of the polarization of political views among Internet users in Ukraine. In Donetsk, Lugansk, and Simferopol subscribers to pro-Russian, pro-separatist, and Antimaidan pages dominated pro-Ukrainian (more than 83 to 17). Only in Kharkiv and Odessa in South-Eastern Ukraine they had a substantial share in the total subscription to top-10 ideologically opposite public pages and groups (38% and 33% correspondingly). In Mykolaiv, Kherson, Zaporizhya, and Dnipro, regional centres of South-Eastern Ukraine, the shares of subscribers to pro-Russian sources of information were only from 15 per cent to 24 per cent. 8 per cent of pro-Russian subscriptions in Kyiv stands out of Central Ukraine. While in Central and North-Eastern Ukraine pro-Russian sources of information in Vkontakte had only 2–6 per cent share. In Western Ukraine, pro-Ukrainian sources of information in Vkontakte totally dominated (98–99% of subscriptions) *(Figure 4)*.

Consequently, easy access to different viewpoints and sources of information on the Internet does not erase territorial differences in political beliefs. Moreover, it creates pre-

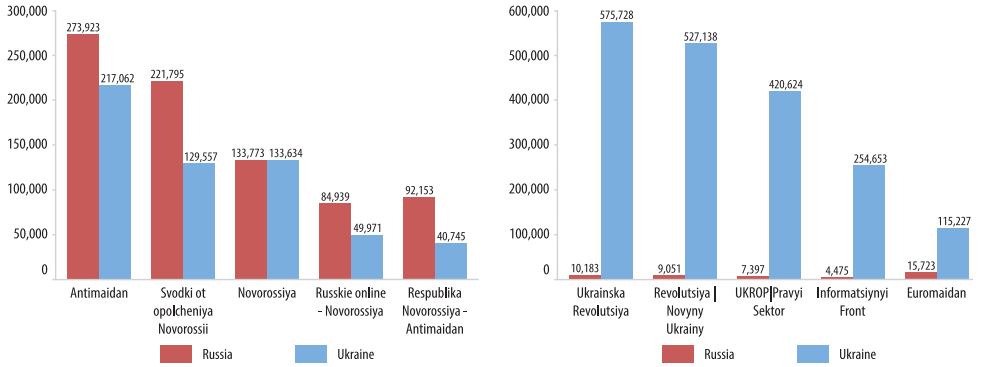

Fig. 3. Number of subscribers and members of top-5 ideologically opposite public pages/groups in Vkontakte by country of origin, 19 February 2015.

conditions for polarization and territorially framed preferences for information sources. For such powerful geopolitical actors as Russia, it opens the door for the informational involvement in the creation of symbolical reality and geopolitical imaginations of people in foreign countries. Primarily this is the case in the neighbouring countries where there is no language barrier, and a shared history could be used as an instrument for unification under one centre position and disunion with the other.

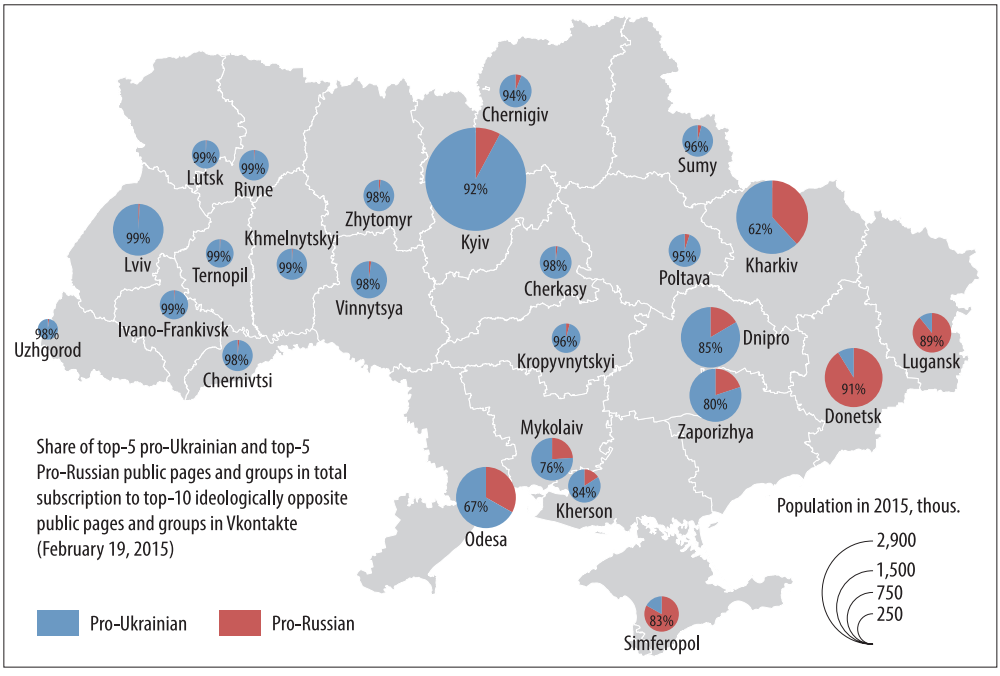

Fig. 4. Territorial differences of subscription to top-10 ideologically opposite public pages/groups in Vkontakte, 19 February 2015.

Conflict in Eastern Ukraine and territorial differences of political behaviour in SNS

After the annexation of Crimea and the start of the war in Eastern Ukraine, the Internet users and Vkontakte members faced the question of reliable sources of information about the events. However, it turns out that the question was rather about suitable sources of information or those that arise due to socialization in particular geographic places. Our study of Vkontakte shows that assumption that space is conquering a place in the era of new technologies (Friedman, Th.L. 2005) is not the case in choosing sources of information about conflicts. Four studied areas in Ukraine show differences in sources of information about Euromaidan revolution and conflict in Eastern Ukraine. In uncontrolled by Ukrainian government territories subscription to top-5 pro-Russian public pages and groups prevailed. Subscription to top-5 pro-Russian public pages is 26.9 per cent in Yenakiieve and 16.3 per cent in Kadiivka (Stakhanov), while a subscription to pro-Ukrainian pages is only 0.70 and 0.85 per cent, respectively *(Table 1).* It was predominant in the reclaimed territories of Bakhmut (Artemivsk) in Donetsk oblast and Lysychansk in Lugansk oblast but with lower numbers of subscription (12.0% and 9.7% respectively).

In territories of Donetsk and Lugansk oblasts, which stayed under Ukrainian government control during the conflict, the numbers of subscription to top-5 pro-Russian public pages and groups was even lower (9.7% in Pokrovsk [Krasnoarmiysk] and 8.0% in Starobilsk), while the use of pro-Ukrainian sources of information was higher (2.5% and 2.7% respectively). In the periphery of the neighbouring regions, subscription to top-5 pro-Ukrainian public pages and groups was already higher than to top-5 pro-Russian (except Izium city in Kharkiv oblast were it was almost equal).

The second part of the study of the conflict territories of Eastern Ukraine sources of information about the conflict included a sample of 450 profiles from studied cities and not only subscription to top-5 ideologically opposite public pages from each side of the conflict, but also other groups and pages and reposts of the information on personal pages feed. As shown in *Figure 5*, the numbers of people who used polarized sources of information about the conflict were even higher, but patterns of the information sources in four studied territories of Ukraine were the same. In profiles from uncontrolled territories, the use of pro-Russian sources of information was predominant; in reclaimed territories, they were substantially lower; in the areas where there was no armed conflict, pro-Ukrainian sources of information were more widespread; and, in the periphery of the neighbouring regions, they already dominated the pro-Russian sources of information.

As a result, Internet users in those territories received a very different message about the understanding of the causes and consequences of the conflict as well as attitudes towards Kyiv or Moscow as centres or even broader geopolitical imaginations of international relations and Russia's role in the world politics.

Geopolitical narratives of pro-Russian public pages and groups in Vkontakte

Despite Pinkerton, A. *et al.* (2011) assumption that the Internet is of geopolitical concern due to uncontrolled and uncontrollable communication, Russian-Ukrainian conflict and representation of the events in Vkontakte show that SNS are of geopolitical concern also because of possible manipulations and controlled messages. Our study shows that in Russian SNS public pages and open groups there are no platforms for communication and exchange of ideas, but these are places of passive communication, where the source of information is just spreading messages to receiving subjects. On the one hand, they have no geographical barriers, but on the other, they are territorially bounded information spaces. For instance, pro-Russian pages and groups bound together people in

Table 1. Subscription to top-5 ideologically opposite public pages/groups in Vkontakte among Vkontakte users of studied cities, February 2015

Studied territories	Sudied cities	Total population in 2015	Number of Vkontakte profiles	Number of subscriptions to top-5							
				pro-Russian public pages and groups				pro-Ukrainian public pages and groups			
				Female	Male	Total	Share, %	Female	Male	Total	Share, %
Uncontrolled territories	Yenakiieve	107,817	23,566	3,054	3,291	6,345	26.92	68	98	166	0.70
	Kadiivka (Stakhanov)	90,133	18,240	1,259	1,722	2,981	16.34	73	82	155	0.85
Reclaimed territories	Bahmut (Artemivsk)	102,594	15,992	837	1,083	1,920	12.01	145	181	326	2.04
	Lysychansk	115,916	20,624	904	1,096	2,000	9.70	196	210	406	1.97
Parts of Donetsk and Lugansk oblasts*	Pokrovsk (Krasnoarmiyks)	75,348	17,231	709	954	1,663	9.65	199	225	424	2.46
	Starobilsk	17,153	7,102	224	347	571	8.04	93	97	190	2.68
Periphery of neighbouring regions	Izium	49,744	11,740	208	287	495	4.22	195	276	471	4.01
	Pavlovgrad	109,566	34,069	330	394	724	2.13	1,114	1,312	2,426	7.12
	Berdiansk	117,509	42,018	441	581	1,022	2.43	1,142	1,336	2,478	5.90

*Territories stayed under state control.

Russia and Donbass, while gradually separating Donbass from other South-Eastern, Central and Western Ukraine. Bourdieu's understanding of television (1998) as symbolical violence could also be used for public pages and groups in SNS as engaged in symbolical violence.

Antimaidan, pro-Russian, and pro-separatists as a group of information sources for Russian speaking people of Ukraine were imposing specific geopolitical visions of the world and conflict in Eastern Ukraine. Content analysis of two of the five most popular pro-Russian pages in Vkontakte posts in 2015 shows that they were creating image of Ukraine as the Other, of South-Eastern Ukraine as a part of greater Russia, of the US and NATO as the main villains, and contradicting image of Europe: (1) negative, as "morally degrading" (in case when it was about Ukrainian inspirations of European integration), and (2) positive, as supporting annexation of Crimea and separatist inspirations in Donbass (mainly about particular positions of right, far-right and sometimes far-left political leaders) *(Figure 6).*

Narratives of Ukraine were oriented to discredit it as a state (notions of failed-state, oligarchs' domination, and weak and illegitimate government) and to accentuate its status as the Other for territories of the armed conflict ("karateli" [chasteners] image and notions of human rights violations). Use of "karateli" as a description of Ukrainian forces and almost everything connected to state apparatus was a crucial element of Russian propaganda in SNS. Important is an appeal to World War 2 memories because it is of high symbolical value for Russian and Ukrainian people. "Karateli" is a word that was used to describe Nazis and their Ukrainian collaborators who were killing local peo-

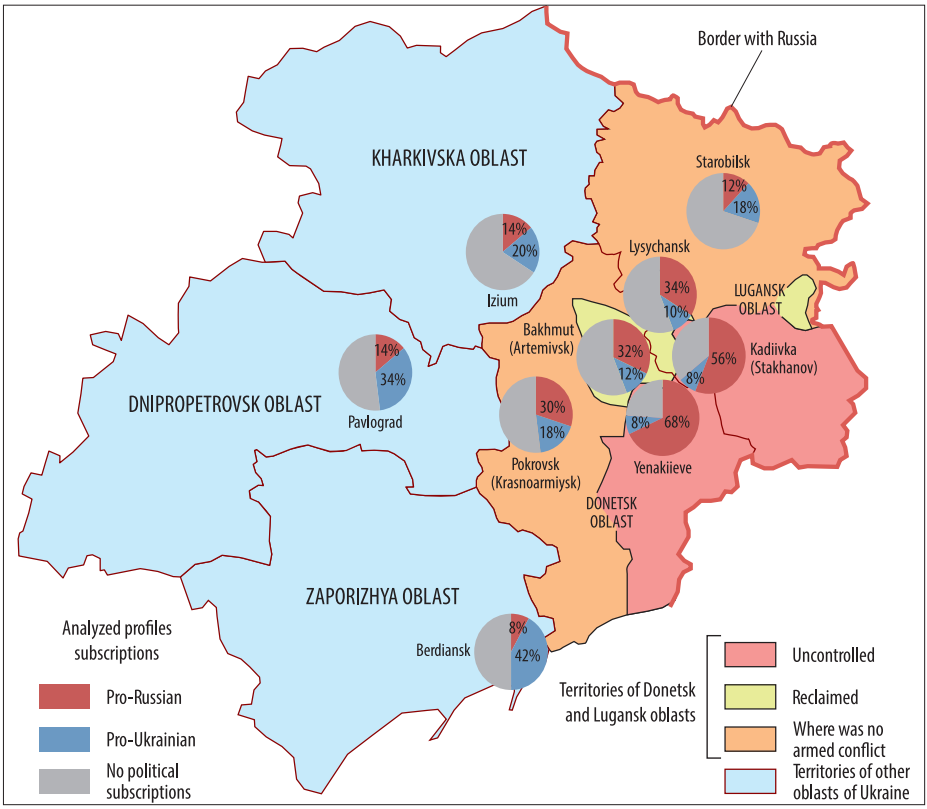

Fig. 5. Sources of information in social networking sites of Internet users from conflict territories and neighbouring regions.

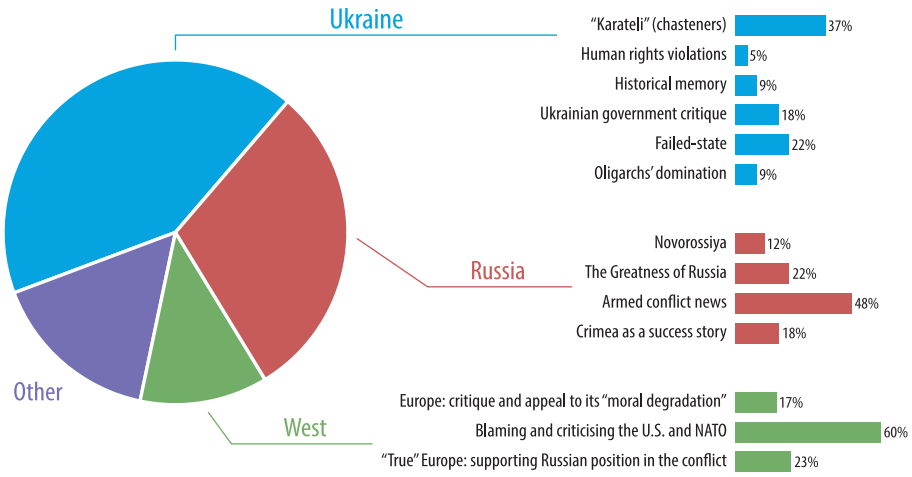

Fig. 6. Content analysis of "Antimaidan" and "Russkie online | Novorossiya" public pages in Vkontakte, 10–25 March 2015.

ple in times of World War 2. Therefore, it was a strong emotional discrediting of Ukraine and the creation of Russia's image as a stronghold in a war with the enemy in the eyes of subscribers of Antimaidan and pro-separatist pages. Moreover, continuous appeal to Kyiv authorities ("Kievskie vlasti") as illegitimate and oppressing local populations in South-Eastern Ukraine was developing the image of Kyiv as the Other, while Moscow was portrayed as a centre, which can protect local populations from the violence of Kyiv authorities.

Narratives about Russia were complicated. First, armed conflict news were given not from neutral or only pro-separatist perspectives. They were following lines of official Russian Federation positions in the conflict. Second, the legitimization of Russian involvement in the conflict was often supported by the narrative of Slavic unity and Russian greatness. It supports conclusions of Kasamara, V. and Sorokina, A. (2012) about imperial ambitions of the Russian population of different social statuses. The studied public pages in Vkontakte were creating particular geopolitical imaginations of Ukrainian territories in their connection to Moscow as a centre. For instance, Crimea annexation legitimization practices were built on notions of "reunification" and historical justice as well as stories of social and economic success after the annexation. South-Eastern Ukraine territories were described using the concept of historical "Novorossiya", which was undermining the role of Kyiv as a legitimate political centre for the region and accentuating its historical and cultural connections to Moscow.

Moreover, these narrative lines were supported by messages about Russian greatness, which included notions of a mighty army, reach natural resources, reach cultural heritage, influence on geopolitical scene, and ability to resist such world powers as the US, which was portrayed as the biggest enemy of Slavic people and "Russkiy mir", undermining post-Soviet space unity, and its economic and political capacities, provoking conflicts in Russia and its "sphere of interests". Geopolitical image of NATO was constructed using the same narrative. Notions of NATO and the US were used interchangeably, while the image of Europe in pro-Russian public pages in Vkontakte was constructed ambiguously. On the one hand, a number of messages in the analyzed content were criticizing Ukrainian inspirations for integration with the EU by portraying European states as "morally degrading", which in the narrative of pro-Russian public pages in Vkontakte means domination of liberal values which are contradicting traditional values of Russians and more broadly Slavic people. At the same time, they were developing a positive narrative of Europe using statements of European far-right, far-left, and pro-Russian politicians and activists.

Conclusions and discussion

Public pages in Vkontakte, which emerged as a reaction to the Euromaidan revolution in Ukraine and later armed conflict in Donbas, were producing broader geopolitical narratives and imaginations of different territories. For example, the image of Crimea as historically Russian land, South-Eastern Ukraine as "Novorossiya" culturally closer connected to Moscow than Kyiv, which was undermining the sovereignty of Ukrainian state and legitimation of Kyiv as a political centre for these territories. Second, these public pages were not just informing people about the conflict, but also suggesting a geopolitical vision of international relations. The United States and NATO were presented as main villains who caused armed conflict by interfering in Ukrainian politics, and Russia image was developed around its greatness as a prerequisite to oppose these enemies. Ukrainian government was discredited using "karateli" concept with the emotional appeal to World War 2.

The consumption of above described geopolitical imaginations and narratives in SNS had clear territorial differences in Ukraine. Subscription to top-5 ideologically pro-Russian public pages and groups in Vkontakte

was predominant to the subscription to top-5 pro-Ukrainian only in Donetsk, Lugansk, and Simferopol regional centers in Ukraine. In Odesa and Kharkiv, for each one subscription to pro-Russian pages were three subscriptions to pro-Ukrainian. Internet users in such cities of South-Eastern Ukraine as Dnipropetrovsk, Mykolaiv, Zaporizhya, and Kherson (whose voting behaviour in years of independence of Ukraine was mainly shifted to the pro-Russian side) in times of armed conflict in Donbas were predominantly using pro-Ukrainian sources of information in Vkontakte. It follows electoral behaviour patterns in 2014 presidential and parliamentary elections in Ukraine, which support the thesis that existing territorial differences in political beliefs are preconditions for the homogenization of subscription to information sources in SNS.

The study of the conflict zone Internet users information sources preferences reveals the influence of the emerged borders and administrative divisions. Cities in the occupied area and reclaimed by the Ukrainian army were using pro-Russian sources of information in Vkontakte more often than other cities in Donetsk and Lugansk regions where was no armed conflict and where Russia-backed separatists were not controlling territory for substantial time. At the same time, administrative borders between Lugansk and Donetsk oblasts on the one side, and Kharkiv, Dnipropetrovsk, and Zaporizhya on the other are vividly visible in the number of subscribers to pro-Ukrainian public pages and groups in Vkontakte.

On the one hand, existing territorial differences in political views frame behaviour of the users on the Internet. On the other hand, SNS as geopolitical tools could be used to polarize society along existing or imagined borders, mobilize people in conflict areas, and spread specific geopolitical narratives. Existing administrative divisions, phantom borders revealed by electoral campaigns, emerged borders of conflict zones frame Internet users' decisions about information sources on SNS. It corresponds with Borondo, J. *et al.* (2014) findings that Internet users cluster themselves in homogeneous groups. However, homogeneity could be based on conformity to a similar vision of the region or place regarding centre-periphery relations, causes of conflict, and a geopolitical picture of the region and the world. Takhteyev, Yu. *et al.* (2012) findings that social ties in Twitter networks depend on the geographical distance between users and are stronger in similar metropolitan areas could have external validity for other SNS and coverage of conflicts in SNS.

The paper's findings show that people living in the same administrative regions of Ukraine and within newly emerged conflict zone boundaries use different sources of information about the conflict. Moreover, those sources of information are not only about agenda setting and coverage of the events but also spread broader geopolitical narratives about actors involved, centre-periphery relation, legitimation of the authorities, and a geopolitical picture of the world. However, we should admit that it does not suggest that all places within administrative borders are homogeneous. Intraregional variability is also of great interest to study in the context of the sources of information preferences in SNS, but it was not in the focus of this paper.

In the case of the post-Soviet space, where the Russian language is understood or even native for populations in the countries neighbouring to Russia, information distributed on the Internet is a powerful tool to promote pro-Russian geopolitical orientations among the local population. Territorial differences of such information consumption depend on existing territorial divisions. However, the reasons why some territories are more vulnerable to specific geopolitical narratives is still under question. These questions in the time of the increased importance of the securitization of cyberspace are of great interest for further geographical research.

REFERENCES

Barrington, L.W. and Herron, E.S. 2004. One Ukraine or many? Regionalism in Ukraine and its political consequences. *Nationalities Papers* 32. (1): 53–86.

Bernazzoli, R.M. and Flint, C. 2009. Power, place, and militarism: toward a comparative geographic analysis of militarization. *Geography Compass* 3. (1): 393–411.

Birch, S. 2000. Interpreting the regional effect in Ukrainian politics. *Europe-Asia Studies* 52. (6): 1017–1041.

Borondo, J., Morales, A.J., Benito, R.M. and Losada, J.C. 2014. Mapping the online communication patterns of political conversations. *Physica A: Statistical Mechanics and Its Applications* 414. 403–413.

Bourdieu, P. 1998. *On Television*. New York, The New Press.

Clem, R.S. and Craumer, P.R. 2008. Orange, blue and white, and blonde: the electoral geography of Ukraine's 2006 and 2007 Rada elections. *Eurasian Geography and Economics* 49. (2): 127–151.

Conroy, M., Feezell, J.T. and Guerrero, M. 2012. Facebook and political engagement: a study of online political group membership and offline political engagement. *Computers in Human Behavior* 28. (5): 1535–1546.

Duvanova, D., Nikolaev, A., Nikolsko-Rzhevskyy, A. and Semenov, A. 2016. Violent conflict and online segregation: an analysis of social network communication across Ukraine's regions. *Journal of Comparative Economics* 44. (1): 163–181.

Duvanova, D., Semenov, A. and Nikolaev, A. 2015. Do social networks bridge political divides? The analysis of VKontakte social network communication in Ukraine. *Post-Soviet Affairs* 31. (3): 224–249.

Frame, A. and Brachotte, G. 2015. Le tweet stratégique: use of Twitter as a PR tool by French politicians. *Public Relations Review* 41. (2): 278–287.

Friedman, Th.L. 2005. *The World Is Flat: A Brief History of the Twenty-First Century*. Farrar, Straus and Giroux.

Gaufman, E. 2015. Memory, media, and securitization: Russian media framing of the Ukrainian crisis. *Journal of Soviet and Post-Soviet Politics and Society* 1. (1): 141–175.

Gemius 2015. *Auditoria Uaneta*. Retrieved on 7 March 2015 from: http://bit.ly/1wddVpA

Goldenberg, J. and Levy, M. 2009. Distance is not dead: social interaction and geographical distance in the internet era. *Computers and Society* 2. 1–22.

Helmus, T.C., Bodine-Baron, E., Radin, A., Magnuson, M., Mendelsohn, J., Marcellino, W., Bega, A. and Winkelman, Z. 2018. *Russian Social Media Influence: Understanding Russian Propaganda in Eastern Europe*. Santa Monica CA, RAND Corporation.

Jackson, L. and Valentine, G. 2014. Emotion and politics in a mediated public sphere: questioning democracy, responsibility and ethics in a computer mediated world. *Geoforum* 52. 193–202.

Johnston, R.J., Shelley, F.M. and Taylor, P.J. (eds.) 1990. *Developments in Electoral Geography*. New York, Routledge.

Kasamara, V. and Sorokina, A. 2012. Imperial ambitions of Russians. *Communist and Post-Communist Studies* 45. (3–4): 279–288.

Kasmani, M.F., Sabran, R. and Ramle, N. 2014. Can Twitter be an effective platform for political discourse in Malaysia? A study of #PRU13. *Procedia – Social and Behavioral Sciences* 155. (October): 348–355.

Kruikemeier, S. 2014. How political candidates use Twitter and the impact on votes. *Computers in Human Behavior* 34. 131–139.

Liber, G.O. 1998. Imagining Ukraine: regional differences and the emergence of an integrated state identity, 1926–1994. *Nations and Nationalism* 4. (2): 187–206.

Lippmann, W. 2017. *Public Opinion*. New York, Routledge.

Lipset, S.M. and Rokkan, S. 1967. Cleavage structures, party systems, and voter alignments: an introduction. In *Party Systems and Voter Alignments; Cross-national Perspectives*. Eds.: Lipset, S.M. and Rokkan, S., Michigan, University of Michigan Free Press, 1–50.

Nam, T. 2012. Dual effects of the internet on political activism: reinforcing and mobilizing. *Government Information Quarterly* 29. Supplement 1. 90–97.

O'Loughlin, J. 2001. The regional factor in contemporary Ukrainian politics: scale, place, space, or Bogus effect? *Post-Soviet Geography and Economics* 42. 1–33.

O'Loughlin, J., Toal, G. and Kolosov, V. 2016. Who identifies with the 'Russian World'? Geopolitical attitudes in Southeastern Ukraine, Crimea, Abkhazia, South Ossetia, and Transnistria. *Eurasian Geography and Economics* 57. (6): 745–778.

Osipian, Al.L. 2015. Historical myths, enemy images, and regional identity in the Donbass insurgency (Spring 2014). *Journal of Soviet and Post-Soviet Politics and Society* 1. (1): 109–140.

Osipian, Ar.L. and Osipian, Al.L. 2012. Regional diversity and divided memories in Ukraine: contested past as electoral resource, 2004–2010. *East European Politics & Societies* 26. 616–642.

Park, Ch.S. 2013. Does Twitter motivate involvement in politics? Tweeting, opinion leadership, and political engagement. *Computers in Human Behavior* 29. (4): 1641–1648.

Peisakhin, L. 2013. *In history's shadow: do formal institutions leave a cultural legacy?* Barcelona, EPSA 2013 Annual General Conference Papers, No 286. Available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2224765

Pinkerton, A. and Benwell, M. 2014. Rethinking popular geopolitics in the Falklands/Malvinas sovereignty dispute: creative diplomacy and citizen statecraft. *Political Geography* 38. 12–22.

Pinkerton, A., Young, S. and Dodds, K. 2011. Weapons of mass communication: the securitization of social networking sites. *Political Geography* 30. (3): 115–117.

Simons, G. 2015. Perception of Russia's soft power and influence in the Baltic States. *Public Relations Review* 41. (1): 1–13.

Steenkamp, M. and Hyde-Clarke, N. 2014. The use of Facebook for political commentary in South Africa. *Telematics and Informatics* 31. (1): 91–97.

Takhteyev, Yu., Gruzd, A. and Wellman, B. 2012. Geography of Twitter networks. *Social Networks* 34. (1): 73–81.

Wang, D.M., Costa, E., Haynes, N., McDonald, T., Nicolescu, R., Sinanan, J., Spyer, J., Venkatraman, S. and Nyuan, X. 2016. *How the World Changed Social Media*. London, UCL Press.

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Suburbs around the Czech provincial city of České Budějovice – territorial arrangement and problems

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Abstract

The article is a contribution to discussions about the territorial arrangement of suburbs, their types and other settlements in suburban zones around post-socialist CEE provincial cities, based on the example of the South Bohemian "one-hundred-thousand" city of České Budějovice, including territorial development problems of suburbs and other settlements. Suburbs, separated from the city by free space, originate there from the original villages. These suburbs are population-growing settlements with the majority of flats in newer houses, immigrants from the city and economically active people working in the city (based on census data and ongoing registrations). Nearby, moderately distant and more distant suburbs occur in three concentric suburban sub-zones around the examined city, in which the population and spatial size of the suburbs gradually diminish. Semi-suburbs with partial suburbanisation and small towns also occur there. The territorial development problems of some suburbs are mainly associated with the disordered (sub)urban sprawl, the inadequate architecture of new houses, the poor quality and capacity of the technical infrastructure, the lack of public transport connections to the city, the absence and low capacity of kindergartens and elementary schools, clashes with recreational second homes, the lack of greenery and the losses of agricultural land.

Keywords: suburbanisation, suburbs, small towns, suburb zone, post-socialist city, Czechia

Introduction

While strong residential suburbanisation in Northwest Europe occurred after World War II, this was not the case in the socialist part of Europe (Musil, J. and Ryšavý, Z. 1983; Szelényi, I. 1983; Bertaud, A. and Renaud, B.M. 1997 and others). The construction of prefabricated housing estates on the edges of socialist cities, especially for people coming from rural areas, cannot be considered as suburbanisation. It was the territorial and population growth of these cities in urbanization. The expansion of the second home recreational cabins and cottages to the hinterlands of Czech and other CEE socialist cities is sometimes referred to as "second home" or "seasonal suburbanisation" (Ouředníček, M. 2007; Vágner, J. *et al.* 2011; Makhrova, A.G. *et al.* 2016). Real residential suburbanisation did not have favourable conditions in the period of socialism in this region. People did not have enough money to build a new family house, there were no developers and construction companies focused on this type of individual construction, there was a lack of building material and the level of car was low (Kubeš, J. 2015a and others). The only scholars who confirmed the weak socialist residential suburbanisation around larger CEE cities were Tammaru, T. (2001) around Tallinn, Brade, I. *et al.* (2009) near Budapest or Mantey, D. and Sudra, P. (2018) around Warsaw.

Since the second half of the 1990s, the situation has changed – suburbanisation became the most significant process transforming settlement system in post-socialist CEE countries (Borén, T. and Gentile, M. 2007,

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and others). Sýkora, L. and Stanilov, K. (2014) described this process of the massive construction of suburban family houses in the hinterlands of the larger post-socialist Central European and Baltic cities after 2000 as a "post-socialist suburban revolution". Commercial suburbanisation began in the mid-1990s (Nuissl, N. and Rink, D. 2005 – Leipzig; Sýkora, L. and Ouředníček, M. 2007 – Prague and Brno). The process of residential suburbanisation started shortly afterwards in the hinterland of Budapest and big East German cities (see Kok, H. and Kovács, Z. 1999, or Brown, D.L. and Schafft, K.A. 2002). In the Eastern part of Germany, this was accompanied by a marked fall in the population of cities (also due to migration to the western part of Germany; Bontje, M. 2005; Nuissl, N. and Rink, D. 2005). Only since 1997 has residential suburbanisation begun to appear in the hinterlands of other Central European post-socialist big cities and at the time of the turn of the millennium around CEE provincial cities (Hardi, T. 2002 – Hungarian Győr; Matlovič, R. and Sedláková, A. 2007 – Slovakian Prešov; Halás, M. *et al.* 2012 – Moravian Olomouc; Szczepańska, A. and Senetra, A. 2012 – Polish Olsztyn; Novotný, L. 2012 – Slovakian Košice). After the strong development of the first decade of the new millennium, residential suburbanisation has weakened somewhat in this region due to the previous strong development, the ongoing economic crisis and the ending population shrinking of cities (Haase, A. and Rink, D. 2015; Kubeš, J. 2015a).

The above and further studies on CEE suburbanisation have focused on suburban migration (1), the population growth of suburbs and suburban zones (2), also in comparison with the population development of cities in the background of the processes of urbanisation, suburbanisation and reurbanisation (3), the demographic and social structure of residents in suburbs (4), the daily mobility of these residents (5), the residential satisfaction of immigrants in the suburbs and their coexistence with native inhabitants (6), the development of suburban house construction (7), commercial suburbanisation (8) and the transformation of land cover in connection with suburbanisation (9). Studies on the territorial arrangement of suburbs and other types of settlements in the suburban zones (10) and the territorial development problems of these types of settlements (11), which are important for this article, are discussed in the third and fourth chapter.

This article is a contribution to discussions about the *delimitation and territorial arrangement of suburbs, their types and other settlements in suburban zones around post-socialist CEE provincial cities* based on the example of the South Bohemian "one-hundred-thousand" city of České Budějovice. Attention is also paid to the *territorial development problems of the suburbs* and other settlements around this city. The article deals with "outer suburbs", which are separated by open space from the continuously urbanised city area (hereinafter referred to as "suburbs"). The need to clarify the post-socialist CEE suburbanisation, specifically in the hinterland of provincial cities, comes in the first step. The next step is to investigate the territorial arrangement of types of suburbs and other settlements around that city. The reason is also the fact that the territorial development problems of settlements located in the suburban zone (the last step) are related to their type.

Suburbanisation around large and provincial cities in post-socialist CEE

*The post-socialist CEE residential suburbanisatio*n is perceived as a process that began in the second half of the 1990s (after a long socialist period with no or little socialist residential suburbanization) in the course of which some inhabitants from the continuously urbanised area of the city (hereinafter referred to as "*the city"*) began to migrate into villages, small cities and other enclaves in the near hinterland of this city. It is especially new suburban family houses that are being built for these mostly younger

middle-income incomers forming families with children. They and other inhabitants of suburbs are connected with the city by daily commuting for work and services. The aforementioned villages and other settlement enclaves are gradually becoming (outer) *suburbs* in this way. Due to the described suburban migration, the population of suburbs is growing and rejuvenating while it is decreasing and aging in the city. Authors from post-socialist CEE define post-socialist CEE residential suburbanisation and suburbs similarly (Ouředníček, M. 2003; Tammaru, T. *et al.* 2009 and others).

In the hinterlands of large post-socialist CEE cities, suburbs are growing mainly from villages, but also from small towns, pre-war or socialist suburban enclaves and socialist recreational cabin settlements. Only sometimes do new suburbs arise as new settlements on "greenfields". Particularly in the closest suburban sub-zone of these large cities, the transformation of the landscape is very strong, sometimes chaotic, creating partially interconnected "carpets" and belts of new solitary and row family houses, less often multi-apartment houses and commercial areas (see Hirt, S. 2007 – around Sofia; Mantey, D. and Sudra, P. 2018 – Warsaw). Commercial suburbanization is strengthening there after the completion of the motorway network (Sýkora, L. and Ouředníček, M. 2007).

Around the smaller provincial CEE cities, the post-socialist suburbs gradually grew out of the near lying villages (derived from maps in Matlovič, R. and Sedláková, A. 2007; Czaková, G. 2009; Halás, M. *et al.* 2012; Novotný, L. 2012; Repaská, G. *et al.* 2017). The emergence of suburbs as new settlements is the exception here (Kubeš, J. 2015b). New family houses for migrants from the provincial city are built in smaller groups at the edges of former villages or on open plots inside them (Zębik, G. 2011); less often these are significantly reconstructed village houses. In these suburbs live the original rural inhabitants which work mainly in agriculture, original rural inhabitants who are commuting to work to the city and new incomers from the city commuting to work to the city. Non-residential suburbanisation is usually weak around provincial cities, because in the fringe parts of these cities, there is enough space for the development of commercial and industrial activities.

Types of suburbs and the spatial extent of suburbanisation in post-socialist CEE

The intensity of suburban migration was a frequent criterion for *"statistical" typologies of suburbs in CEE*. Using suburban migration, Leetmaa, K. and Tammaru, T (2007) defined nearby and distant suburbs and also satellite small towns in the hinterland of the city of Tallinn in Estonia. Tanaś, J. (2013) did it similarly around Poznań. On the basis of suburban migration and also construction of suburban homes, Špačková, P. *et al.* (2016) identified 4 zones of residential suburbanization in the hinterland of Prague and other Czech towns. Suburban migrations, prices and the numbers of transactions involving building plots near the Polish city of Olsztyn were input data for the typology of suburban municipalities in Szczepańska, A. and Senetra, A. (2012). A comprehensive approach was chosen by Halás, M. *et al.* (2012), when they identified types of suburban municipalities on the basis of suburban migration, commuting to work and the construction of flats in the hinterland of the Moravian city of Olomouc. Marcińczak, S. (2012) defines suburban belts around Łódź according to commuting to work. Also in Tammaru, T. (2005), different intensities of commuting to work from suburbs to the city form two suburban sub-zones around Tallinn. Vobecká, J. and Piguet, V. (2012) took a similar approach to the hinterlands of the cities in the Czech Republic. The typology of suburban municipalities in Šveda, M. *et al.* (2016) is based on extensive statistics on migration, the construction of flats, their prices and the structure of land-use.

Other authors define *morphological typologies of suburbs in CEE*. Zębik, G. (2011) and Repaská, G. *et al.* (2017) developed a typology of suburbs in Poland and Slovakia on the

basis of the space-structural arrangement of new houses in suburbs formed from earlier villages. Dinić, M. and Mitković, P. (2016) delineated protrusions of new suburban fabric penetrating from the city to the surrounding landscape and suburban-rural satellites. Existing typologies of suburbs use three alternative approaches: statistical, based on available data; morphological, based on a detailed analysis of spatial structures and genetic; each with certain limitations – Mantey, D. and Sudra, P. (2018). The authors created a morphological typology of Warsaw's suburbs, when they first determined the spatial scale (block, neighbourhood, settlement, district or municipality) and then evaluated the period of origin, the prevailing type of investment, access to the city by public transport, and finally determined the morphology of suburbs in the form of the spatial interaction of suburban fabric with the city (linear, leap frogging, etc.) the prevailing type of street layout (street grid, cul-de-sac streets, along a main street). The ground plan, height, volume and shape of the building are evaluated as secondary, as well as the connection to the original settlements.

Sýkora, L. and Ouředníček, M. (2007) delineated two zones of suburban municipalities in the Prague hinterland, the first is located between the continuously urbanised Prague and the administrative boundary of this city, while the second is defined by surrounding municipalities with a greater construction of suburban houses and a higher level of commuting to work to the city. Kok, H. and Kovács, Z. (1999) identified 4 types of municipalities in Budapest's hinterland from the point of view of their representatives' willingness to construct houses in their area for inhabitants from Budapest.

The *spatial extent of post-socialist CEE suburbanisation* mostly depends on the population size of the city. Suburbs can now be found up to 25–30 kilometres from the edge of a city in the case of one-millionth Prague or Warsaw (especially along highways and railroads), 20 kilometres in the case of Czech Brno, Estonian Tallinn or Slovakian Bratislava with 400,000 inhabitants (derived from Kährik, A. and Tammaru, T. 2008; Špačková, P. *et al.* 2016; Šveda, M. *et al.* 2016; Wolny, A. and Źróbek, R. 2017) and up to 13 kilometres in the case of the Bohemian provincial one-hundred-thousand city of České Budějovice and similarly sized cities in post-socialist Central Europe (Matlovič, R. and Sedláková, A 2007 – Slovakian Prešov; Czaková, G. 2009 – Slovakian Nitra; Halás, M. *et al.* 2012 – Moravian Olomouc). However, the definition of suburbs in studies is important in this respect.

Western typologies of suburbs reflect several decades of development of suburbanisation. The North American urban scholars have created a number of studies focused on the types of US and Canadian suburbs (see references in Bourne, L.S. 1996, or Mikelbank, B.A. 2004). They are coming out of socio-economic, demographic, ethnic, functional, morphological, developmental and positional features of suburbs (Brown, M.A. 1981; Logan, J.R. and Golden, R.M. 1986; Orfield, M. 2002; Mikelbank, B.A. 2004; Hanlon, B. 2009; Hall, M. and Lee, B. 2010 and others). Some American and Canadian suburbs are larger than the towns of Central and Eastern Europe. Some suburbs are 50 or more km away from the city (Davis, J.S. *et al.* 1994, or Mikelbank, B.A. 2004). It is a quantitatively, qualitatively and developmentally (historically) different story. In CEE countries, there is not yet experience with the US very far "exurbs" (Davis, J.S. *et al.* 1994), very large "superb-urbs" (Bourne, L.S. 1996), "ethnic suburbs" (Hanlon, B. 2009) or the suburban "edge cities" (Garreau, J. 1992) with many job opportunities and services for suburban people.

There are few publications dedicated to the distinction and characteristics of suburbs around Western European cities. Baccaini, B. (1997) characterizes the demographic types of Parisian suburbs, Bontje, M. and Burdack, J. (2005) sought the analogy of American "edge cities" around Paris and in central Holland, Montagné Villette, S. and Hardill, I. (2007) described spatial peripheries, social peripheries or communities with

a cultural identity in the suburban zone of Paris, and Motte-Baumvol, B. *et al.* (2010) defined variously car-dependent outer Parisian suburbs. Studies on suburbanisation in Great Britain and the diversity of British suburbs, especially in Greater London, are more numerous – Vaughan, L. *et al.* (2009) and the literature in this study. The London suburbs have been developing for over 200 years. In recent years, many have been physically and socially transformed.

Study area

The provincial, second- to third-tier, "one-hundred-thousand" *city of České Budějovice* is based on the Vltava River in South Bohemia, 130 km to the south of Prague and 60 km to the north of Linz in Austria. It is the capital of the South Bohemian Region, which had 640,000 inhabitants in 2017. Currently (2017), the city (continuously urbanised area) has 91,978 inhabitants, compared with 98,026 in 1998, when post-socialist suburbanisation began there. The decline is mainly due to emigration to suburbs (suburban migration). The latest data over the past 5 years shows population stabilization. The municipality of the city is slightly larger because it also includes several suburbs and villages near the city.

On the basis of the suburbanisation defined, *the agglomeration of the city of České Budějovice* includes the city, suburbs, semi-suburbs and small towns in suburbanised hinterland, including two villages inside it. Based on the analyses done in this article, at present (2017), about 32,500 people live in 53 suburbs and others in semi-suburbs and small towns Unlike in other Czech cities, there was weak suburbanisation during socialism between 1970 and 1989. Non-residential suburbanisation is weak in the study area. For a long time, the city has been waiting for the construction of a freeway from Prague to Linz, which is currently being built on the eastern edge of the city and which will attract commercial suburbanisation.

Methodology of delimitation, typology and analysis of suburbs around the provincial city of České Budějovice

Delimitation of suburbs

The delimitation and typology of suburbs around the (smaller) provincial city of České Budějovice is based on the characteristics of post-socialist CEE suburbanisation and suburbs around provincial cities (Chapter 2), the above-mentioned typologies of suburbs (Chapter 3) and from experience with gradual suburbanisation research around the study city (Kubeš, J. 2009, 2015b). The following *criteria for delimitation suburbs* used in the study area can be applied to similar Czech and possibly CEE provincial cities and their hinterlands. The criteria can be divided into positional (a–d), population-social (e–g) and morphological (h).

The suburb is a geographically delineated mostly compact settlement (criterion a), which emerged from the original village (b; exceptions exist) and which is territorially separated from the city and from other settlements (c). The suburb is an administrative part of a municipality (d; exceptions). Commercial areas and buildings may be located in suburbs (old or newer thanks to commercial suburbanization), but territorially separated commercial areas without residents are not considered as suburbs in this study.

The suburb should grow in terms of population (e), mainly due to suburban migration. At least half of the population of the suburb has come from the city (and other towns) to the suburb since 1970 (f). Czech migration data has only been available since 1990 (however, Kára, J. and Kučera, T. 1986 describe the socialist migration from České Budějovice to the near suburbs), so it was necessary to set a criterion to 40 per cent +. Suburb residents should be closely connected with the city through commuting for work and services. Most economically active residents in suburbs commute to work to the city (or to the surrounding suburbs; g). It was necessary to set this criterion to 40 per cent + because the

Czech 2011 census was not complete in this regard (Špačková, P. *et al.* 2016). Most of the flats (50% +) in a suburb should be relatively new – built since 1970, when family houses of suburban type (unconnected with farming) were built in the village/suburb later (h). This criterion ensures the presence of new non-farm houses in the suburbs. New houses can take the form of individual or row family houses of a suburban type or, rather rarely, smaller multi-apartment houses. They mostly grow up in groups at the edges of the original village/suburb later (Kubeš, J. 2015a). Criteria "e" and "f" apply only during the development of suburbanisation.

Typology of suburbs and other settlements

The *concentric-genetic typology of suburbs* in suburban zone of the provincial city of České Budějovice takes into consideration the distance of the suburb from the city (by road) and the related time of origin of the suburb from a village. The location and time of emergence of the suburbs is reflected in other features of the suburbs. The concentric chain of large *nearby suburbs* is located in the first suburban sub-zone of the semi-urban landscape. Weak residential suburbanization began here in the 1970s and 1980s under socialism. The concentric chain of post-socialist *moderately remote suburbs* forms the second suburban sub-zone of the semi-rural landscape from the new millennium. *More distant suburbs* appear after 2005 in the rural landscape.

There are also settlements in the suburban zone where suburbanisation is beginning to develop but they still do not meet the criteria "f" (suburban migration) and "h" (new flats) for suburbs. These settlements can be considered as *semi-suburbs* (Kubeš, J. 2015b). Criterion "f" is reduced to 25 per cent for them, "h" to 30 per cent, while other criteria remain. *Small towns* with 1,500–5,000 inhabitants and with the majority of indigenous inhabitants have also existed for a long time. These small towns around a provincial city are not suburbs because only a few migrants from the city come to them. A suburban-defined *agglomeration of the provincial city* will be delineated through the city, suburbs and semi-suburbs, including small towns and residual villages lying within the agglomeration.

Initial data for the delimitation and typology of suburbs and other settlements around the study city was taken from Czech censuses (1970, 1980, 1991, 2001 and 2011) – the number of inhabitants, the age of flats and the number of commuters to work from Czech continuous registration – the number of inhabitants (2017), new flats (2011–2017) and migrants (1990 – 2017). Commuting and migration data for municipalities are recalculated to data for individual settlements. Analyses of suburbanisation using municipalities are not appropriate because the municipality of a city includes not only a city but also several of the nearest suburban municipalities are often made-up of different settlement types – of suburbs, semi-suburbs or villages.

Analysis of territorial development problems of suburbs and other settlements

The authors of many studies mention territorial development problems caused by strong post-socialist CEE suburbanisation, but only some of them deal with these problems primarily. Haase, D. and Nuissl, H. (2007) evaluated Leipzig's suburbanisation in terms of its impact on the water environment in the suburban landscape (reduced water retention, increased flood hazard, water quality degradation). Petrova, S. *et al.* (2013) discuss issues of low carbon satellite settlements in Czechia and Kroll, F. *et al.* (2012) assessed the supply and demand of different ecosystem services in the suburban zone of Leipzig. A number of articles specify agricultural land losses due to suburban construction (Spilková, J. and Šefrna, L. 2010; Grigorescu, I. *et al.* 2012; Stanilov, K. and Sýkora, L. 2012; Roose, A. *et al.* 2013). Hirt, S. (2007) draws attention to the blurring of Sofia's urban edge due to poorly regulated suburbanisation and

to the architectural problems within Sofia's suburbs. Mantey, D. and Sudra, P. (2018) emphasize the need to create public spaces in new suburban areas in Warsaw's suburbs. The intrusion of residential suburbanisation into recreational cabin settlements is a current spatial planning problem (Vágner, J. *et al.* 2011; Leetmaa, K. *et al.* 2012, or Nuga, M. *et al*. 2015). Ott, T. (2001) points to the monotony of construction forms and styles of new constructions around the East German provincial city of Erfurt. According to Palang, H. and Peil, T. (2010), Spilková, J. and Perlín, R. (2010), Halleux, J.M. *et al.* (2012), Kladivo, P. *et al.* (2015) or Mantey, D. and Sudra, P. (2018), post-socialist spatial planners and building officials should regulate the construction of houses in individual suburbs on the basis of the spatial plan of the entire agglomeration and adhere to the regulations of construction contained in the spatial plans of individual suburban municipalities.

The simple assessment of *territorial development problems of individual suburbs*, other settlements and their types in the study area is carried out on the basis of field surveys, aerial photographs, municipal spatial plans and interviews with local experts. Specifically, settlements with disordered (sub)urban sprawl in the form of poorly organized built-up areas, streets and roads (U), the inappropriate and monotonous architecture of new (suburban) houses and their inconsistency with original houses (A), the insufficient quality and capacity of technical infrastructure in connection with a new (suburban) development (T), previously created recreational cabin areas and with the negative impacts of suburban development on them (R), a lack of woody greenery inside new (sub)urban areas (G), few connections of public transport into the city (P), the absence or small capacity of kindergartens and schools in connection with the increase in the number of children due to suburbanisation (S) and with a large devouring of quality agricultural land in connection with suburban construction (L) will be searched for. Based on the occurrence of these territorial development problems, further suburban development in the form of the construction of new houses in individual settlements (and their types) is proposed in a moderate (++), small (+) or near zero (–) range.

Delimitation and types of suburbs around the provincial city of České Budějovice

If the *agglomeration of České Budějovice* is defined as the sum of the city, its suburbs, semi-suburbs and also small towns between them (+ two villages inside) (*Figure 1*) then it currently (2017) has about 147,400 inhabitants (*Table 1*). Most inhabitants still live in the city (92,000 – 62.4%), less in growing suburbs (32,500 – 22.0%), stabilized small towns (18,300 – 12.4%) and the least in semi-suburbs (4,500 – 3.0%). Due to the gradual transformation of villages and semi-suburbs to suburbs, the number of suburbs rose from about 13 (1989), to 41 (2008) (Kubeš, J. 2009) and to 53 (2017). Since 1970, the population of contemporary suburbs has doubled *(Table 1)* and their area has increased by 75 per cent *(Table. 2).* There is a relatively mixed set of suburbs and other settlements with regard to the timing of suburban migration, home construction, population growth, with regard to distance from the city, current size by population and area and with regard to territorial development problems in them.

The most important suburbs are the *nearby suburbs* forming a concentric chain in the first suburban sub-zone of the semi-urban landscape, both in numbers (22 suburbs) and in population (64.2% of population in suburbs). Suburban construction in them and their population growth began in about the 1970s within weaker socialist residential suburbanisation. Over 68 per cent of newer flats (built after 1970) in these suburbs and their population have more than doubled since 1970. Seven of them exceeded 1,000 inhabitants. In the study area, they lie within 4 kilometres of the edge of the city. The concentric chain of post-socialist *moderately distant suburbs* (21 suburbs) and their surroundings forms the second suburban sub-zone with a "semi-

Table 1. Values of selected criteria for suburbs, their types and other settlements in the agglomeration of city of České Budějovice, 2017

Type of settlements	Number of settlements	Share of			Population growth[4]		Population
		flats in newer houses[1]	immigrants from the city[2]	commuters to work to the city[3]	1970 = 100	1990 = 100	
The city	1	59.75	–	–	1.21	0.96	91,978
Suburbs	53	67.15	57.30	58.92	2.00	1.65	32,500
Nearby suburbs	22	68.25	59.93	55.83	2.21	1.68	20,896
Moderately distant suburbs	21	66.22	54.88	58.39	1.85	1.72	8,238
More distant suburbs	10	63.79	48.31	71.40	1.45	1.41	3,366
Semi-suburbs	23	48.28	55.79	59.81	1.23	1.37	4,470
Small towns	7	50.28	33.29	42.90	1.34	1.13	18,317
Villages	3	32.69	46.71	59.25	0.77	0.86	167
Suburban zone of the city[5]	86	62.43	54.27	54.71	1.69	1.45	55,454
Agglomeration of the city[6]	87	60.74	–	–	1.36	1.09	147,432
Compared villages[7]	9	32.08	31.15	45.02	0.56	0.87	559

Notes: [1]The share of flats in newer houses constructed in 1970–2017 out of all flats in 2017; [2]The share of immigrants from the city (and from other cities, towns and suburbs) migrating in 1990–2017 out of all population in 2017; [3]The share of commuters to work to the city (and also to other towns) out of all economically active population in 2011; [4]Index of population growth 1970–2017 and 1991–2017; [5]This includes suburbs, semi-suburbs, small towns, and two small villages; [6]This includes also the city; [7]These villages lying behind the agglomeration were monitored for comparison. *Sources*: Censuses and continuous registrations of inhabitants in the Czech Republic.

Table 2. Other characteristics and territorial development problems of types of suburbs and other settlements in the agglomeration of city of České Budějovice, 2017

Type of settlements	Average					Territorial development problems of suburbs[4]	Further construction of new houses[5]
	distance from the city[1], km	number of population		settlement area in hectares		distance of nearby settlement[3], km	
		2017	1970	2017	1970[2]		
Nearby suburbs	1.9	1,006	454	36	18	1.3	U, A, R ,G, S, L	–
Moderately distant suburbs	5.0	392	209	16	10	2.1	A, T, R, G, P, S, L	++
More distant suburbs	10.5	424	288	15	11	2.6	A, T, R, P, S, L	++
Semi-suburbs	7.5	179	145	7	5	2.4	A, T, R, P	++
Small towns	7.7	2,957	2,183	93	82	2.4	U, G, L	+

Notes: [1]From the edges of the city to the centres of the settlements; [2]This includes houses, other buildings, communal spaces and gardens around houses; [3]Among the edges of settlements in suburban sub-zone; [4]Selected territorial development problems of types of settlements (more frequent with bigger letters) – the letters are explained in the text; [5]The possibility of construction of new houses: in a moderate (++), small (+) or near zero (−) extent. *Source:* Own research.

rural landscape" usually up to 8 kilometres away from the city. The population of these suburbs increased primarily after 2000. Their current approximate population size is about 392 inhabitants (whereas for the previous type it was 950). They have retained their village appearance and there are more extensive agricultural areas and ponds in their surroundings, to the east and south even smaller forests. Their development is mostly well-regulated by spatial planning (Kubeš, J. 2015a).

The territorially disordered set of post-socialist *more distant suburbs* (10 suburbs) is still small in number. These suburbs are located primarily in the southwest (in the undulating and partly wooded rural landscape) at a distance up to 13 kilometres from the city and attract more affluent and environmentally oriented inhabitants of České Budějovice (according to the interviews done in these suburbs). The mentioned moderately distant and more distant suburbs in the study area can be classified as "suburbs with a rural character" due to their small population size, greater distance from the city, rural image and incidence of rural and natural landscapes around them.

Semi-suburbs (23; mainly in the third subzone) are located at a distance of up to 13 kilometres from the city and they have a predominantly village appearance. They could also be settlements where the construction of new houses is limited (flood risk, a lack of building plots). Inhabitants of semi-suburbs also commute to work primarily into České Budějovice *(*see *Table 1).* Also semi-suburbs infringe the circular distribution of the agglomeration because they exist mainly on the northwest or southwest of the study area where there are substantial roads leading from the city or valuable landscape *(*see *Figure 1). Small towns* (7) are of a varying size and they are still slowly growing. In the socialist period, small industrial plants were in these small towns. However, they were closed down in the course of the transformation in the 1990s, and thus local inhabitants – when they are not employed in local services – commute to work to the city (see *Table 1*). These towns have a small-town core with town architecture and facilities of services. New family houses were built on the edges of small towns but for the most part these are for local inhabitants.

Territorial development problems of suburbs around the provincial city of České Budějovice

Especially the large nearby suburbs near the city borders (e.g. Hrdějovice, Dobrá Voda, Včelná or Litvínovice) can be characterized by symptoms of disordered (sub)urban sprawl in the form of poorly organized built-up areas (chaotic urban structure with no centre, with poorly arranged streets, with commerce and industry enclaves, with intensive road traffic; "U" in *Figure 1* and *Table 2*). In the east, nearby suburbs are heavily hit by the ongoing highway construction. Suburbanisation damages the architectural environment of the original villages, the existing suburbs, mainly due to the inappropriate architecture of new suburban family houses compared to the original farmhouses and due to the monotonous and foreign architecture of these new houses ("A" in *Table 2*; see Kubeš, J. 2015a). Small towns with small-town architecture and urbanism do not usually have such problems. The technical infrastructure of suburbs (water supply, sewerage, WWTP, electrical station) is sometimes not ready for a substantial increase in the number of houses and inhabitants ("T" in *Table 2*). However, it does not usually apply to nearby suburbs that are connected to the technical infrastructure of the city or have already dealt with these problems earlier. Small towns also do not have technical infrastructure problems. Recreational cabin areas may be adversely affected by expanding suburbs and some recreational cabins are inappropriately converted into permanently occupied houses ("R" in *Figure 1* and *Table 2*; similarly, Leetmaa, K. *et al.* 2012 around Tallinn).

The lack of woody greenery in new suburban areas in suburbs is particularly noticeable in nearby suburbs with dense buildings and small plots around houses ("G" in *Table 2*).

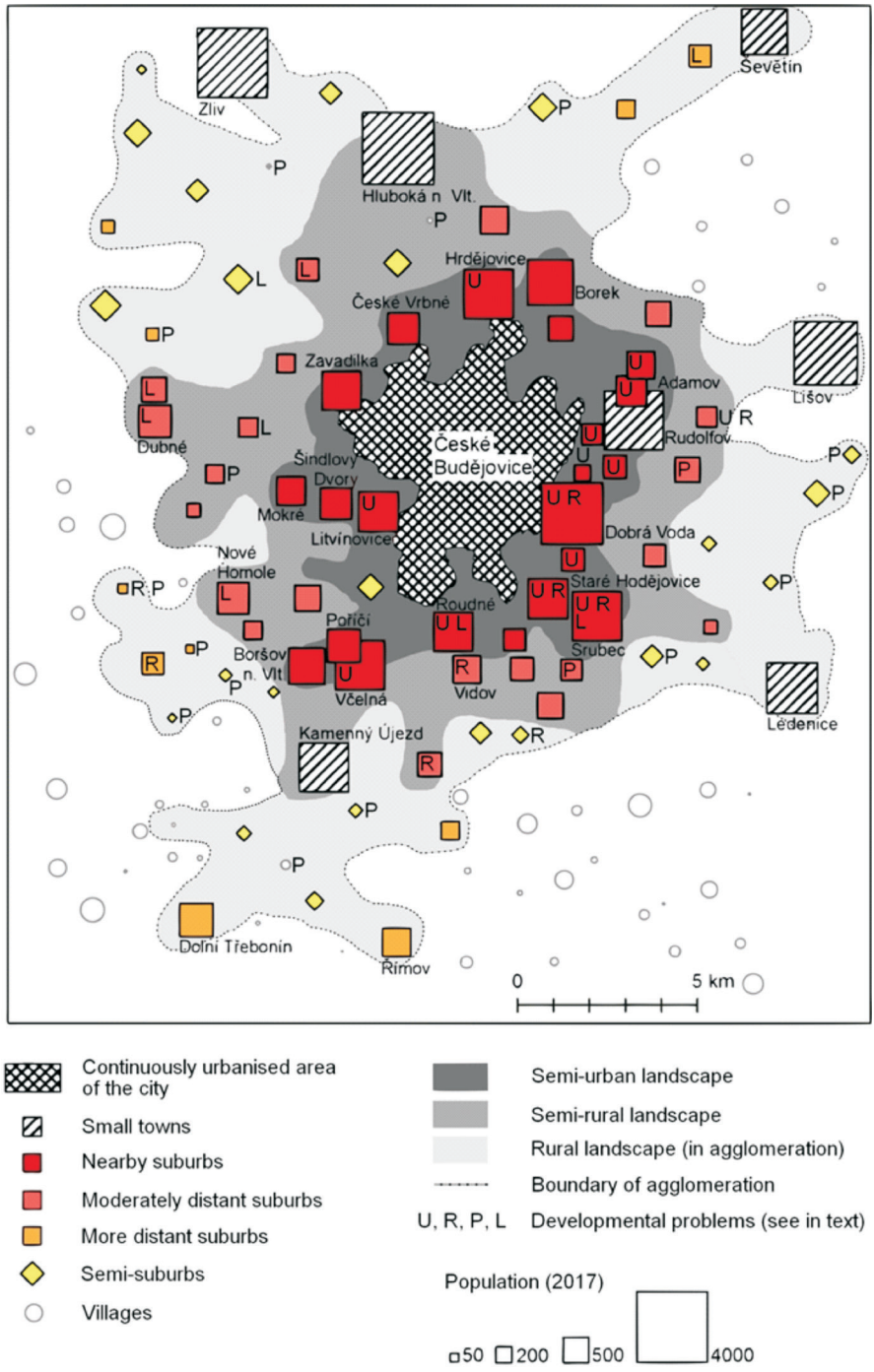

Fig. 1. Suburbs, their types, semi-suburbs, small towns and suburban sub-zones around the city of České Budějovice (2017). *Source:* Own processing, GIS by Tomíček, F.

Moderately distant and more distant suburbs, as well as semi-suburbs, are mostly surrounded by woody greenery that penetrates to the interior of these settlements. Few public transport connections into the city have suburbs and semi-suburbs if they are located outside the main roads and railways and if city public transport does not reach them ("P" in *Figure 1* and *Table 2*). The nearby suburbs are well connected to the city via city public transport (city trolleybuses and buses). Due to the sharp increase in the number of children in the suburbs after the arrival of young families from the city, the capacity of local kindergartens and elementary schools is often insufficient (similarly Kladivo, P. *et al.* 2015 in Olomouc's suburbs). Suburbanisation creates irreversible changes to the landscape (Sýkora, L. and Ouředníček, M. 2007) and often "devours" quality agricultural land ("L" in *Figure 1* and *Table 2*; literature in the methodological chapter). Since 1970, the suburbs and semi-suburbs have absorbed 578 hectares of unbuilt (largely agricultural) land, small towns absorbed 77 hectares (both calculated from the data in *Table 2*) and České Budějovice expanded by 950 hectares.

Suburbanisation should be regulated through spatial planning. The key task is the re-introduction of a spatial plan for the whole agglomeration of the city (see citations in the methodological chapter). This plan should regulate the further construction of houses in suitable settlements and locations in them.

Conclusions

České Budějovice grew in population until the beginning of the post-socialist suburbanisation in 1998; thereafter the population has been decreasing, mainly due to suburban migration. The latest data shows population stabilization in the city: 91,735 in 2011 and 91,978 in 2017. The suburban zone of this city has a more or less concentric character with protrusions along the major roads to the northwest, northeast and east and into the aesthetically and naturally valuable landscape of the Šumava foothills in the southwest (see *Figure 1*). The number of suburbs around the city increased from 13 (1989) to 53 (2017), gradually according to individual suburban sub-zones. The population of former villages and today's suburbs has doubled since 1970 (from 2008 slower growth). Suburbs are territorially separated and relatively compact settlements originating from the villages.

Different types of suburbs and other settlements in individual suburban sub-zones can be distinguished. The first concentric suburban sub-zone is characterised as a semi-urban landscape with a chain of larger nearby suburbs. Some of these suburbs have signs of disordered (sub)urban sprawl, a lack of greenery and they are loaded with intense road traffic. Nearby suburbs should no longer continue to expand. Smaller moderately distant suburbs are distributed in a chain in the semi-rural landscape (the second concentric suburban sub-zone). They can be further developed if they do not "eat" quality agricultural land and nature in the surrounding area and have good connections to the city and the availability of schools and other services. Stabilized small towns may help alleviate the harmful monocentric settlement system in the agglomeration of the city in some ways. More distant suburbs and semi-suburbs in the third suburban sub-zone have similar territorial development problems as moderately distant suburbs. The third sub-zone does not have a sharply defined outer boundary, and it forms protrusions up to a distance of 13 kilometres from the edge of the city.

Nearby, moderately distant and more distant suburbs and semi-suburbs in the suburban zone and also villages lying at greater distances are settlement elements on the urban-rural continuum in the hinterland of the provincial city of České Budějovice. This continuum is "disturbed" by small towns, only a few of which are affected by suburbanisation. A similar territorial arrangement of suburbs created by "suburban leapfrog-to-villages development" can be found around other similar Czech provincial cities, such as Hradec Králové, Pardubice or Olomouc (based on local literature, field surveys and

aerial photographs). Suburbs in the suburban zone of one-millionth Prague are more diverse in terms of the types examined in this article. In addition to the suburbs emerging from the villages, there are also large suburbs in the form of suburban small towns created by strong post-socialist suburbanisation from original settlements (small towns or villages), pre-war, socialist and post-socialist suburban enclaves outside original settlements (especially near the city) and suburban enclaves formed from recreational cabin settlements (Vágner, J. *et al.* 2011 and others). Prague's suburban zone reaches up to 30 km from Prague (Špačková, P. *et al.* 2016).

REFERENCES

Baccaini, B. 1997. Types and causes of recent growth in the suburban districts of Ile-de-France. *Population* 52. (2): 291–325.

Bertaud, A. and Renaud, B.M. 1997. Socialist cities without land markets. *Journal of Urban Economics* 41. (1): 137–151. DOI: https://doi.org/10.1006/juec.1996.1097

Bontje, M. 2005. Facing the challenge of shrinking cities in East Germany: The case of Leipzig. *GeoJournal* 61. (1): 13–21. DOI: https://doi.org/10.1007/s10708-005-0843-2

Bontje, M. and Burdack, J. 2005. Edge cities, European-style: examples from Paris and the Randstad. *Cities* 22. (4): 317–330. DOI: https://doi.org/10.1016/j.cities.2005.01.007

Borén, T. and Gentile, M. 2007. Metropolitan processes in post-communist states: an introduction. *Geografiska Annaler: Series B, Human Geography* 89. (2): 95–105. DOI: https://doi.org/10.1111/j.1468-0467.2007.00242.x

Bourne, L.S. 1996. Reinventing the suburbs: Old myths and new realities. *Progress in Planning* 46. (3): 163–184. DOI: https://doi.org/10.1016/0305-9006(96)88868-4

Brade, I., Smigiel, C. and Kovács, Z. 2009. Suburban residential development in post-socialist urban regions: The case of Moscow, Sofia, and Budapest. In *German Annual of Spatial Research and Policy 2009*. Ed.: Kilper, H., Berlin–Heidelberg, Springer, 79–104. DOI: https://doi.org/10.1007/978-3-642-03402-2

Brown, D.L. and Schafft, K.A. 2002. Population de-concentration in Hungary during the post-socialist transformation. *Journal of Rural Studies* 18. (3): 233–244. DOI: https://doi.org/10.1016/S0743-0167(01)00046-8

Brown, M.A. 1981. A typology of suburbs and its public policy implications. *Urban Geography* 2. (4): 288–310. DOI: 10.2747/0272-3638.2.4.288

Czaková, G. 2009. Development and formation suburban hinterland of the city of Nitra. *Geographia Cassoviensis* 3. (2): 34–42.

Davis, J.S., Nelson, A.C. and Dueker, K.J. 1994. The new burbs: the exurbs and their implications for planning policy. *Journal of the American Planning Association* 60. (1): 45–59. DOI: https://doi.org/10.1080/01944369408975551

Dinić, M. and Mitković, P. 2016. Suburban design: from "bedroom communities" to sustainable neighbourhoods. *Geodetski Vestnik* 60. (1): 98–113. DOI: https://doi.org/10.15292/geodetski-vestnik.2016.01.98-113

Garreau, J. 1992. *Edge city: Life on the New Frontier*. New York, Anchor Books.

Grigorescu, I., Mitrică, B., Kucsicsa, G., Popovici, E.A., Dumitrascu, M. and Cuculici, R. 2012. Post-communist land use changes related to urban sprawl in the Romanian metropolitan areas. *Human Geographies-Journal of Studies & Research in Human Geography* 6. (1): 35–46. DOI: https://doi.org/10.5719/hgeo.2012.61.35

Haase, A. and Rink, D. 2015. Inner-city transformation between re-urbanisation and gentrification: Leipzig, eastern Germany. *Geografie* 120. (2): 226–250.

Haase, D. and Nuissl, H. 2007. Does urban sprawl drive changes in the water balance and policy?: The case of Leipzig (Germany) 1870–2003. *Landscape and Urban Planning* 80. (1–2): 1–13. DOI: https://doi.org/10.1016/j.landurbplan.2006.03.011

Halás, M., Roubínek, P. and Kladivo, P. 2012. Urban and suburban space of the city of Olomouc: theoretical approaches, definition, typology. *Geografický časopis/Geographical Journal* 64. (4): 289–310.

Hall, M. and Lee, B. 2010. How diverse are US suburbs? *Urban Studies* 47. (1): 3–28. DOI: https://doi.org/10.1177/0042098009346862

Halleux, J.M., Marcińczak, S. and van der Krabben, E. 2012. The adaptive efficiency of land use planning measured by the control of urban sprawl. The cases of the Netherlands, Belgium and Poland. *Land Use Policy* 29. (4): 887–898. DOI: https://doi.org/10.1016/j.landusepol.2012.01.008

Hanlon, B. 2009. A typology of inner-ring suburbs: Class, race, and ethnicity in US Suburbia. *City & Community* 8. (3): 221–246. DOI: https://doi.org/10.1111/j.1540-6040.2009.01287.x

Hardi, T. 2002. Szuburbanizációs jelenségek Győr környékén (Suburbanisation phenomena around city of Győr). *Tér és Társadalom* 16. (3): 57–83.

Hirt, S. 2007. Suburbanizing Sofia: Characteristics of post-socialist peri-urban change. *Urban Geography* 28. (8): 755–780. DOI: http://dx.doi.org/10.2747/0272-3638.28.8.755

Kährik, A. and Tammaru, T. 2008. Population composition in new suburban settlements of the Tallinn metropolitan area. *Urban Studies* 45. (5–6): 1055–1078. DOI: https://doi.org/10.1177/0042098008089853

Kára, J. and Kučera, T. 1986. Migrační bilance obcí v zázemí velkých měst (Migration balance of municipalities in the hinterlands of large Czech cities). In *Nové tendence ve vývoji osídlení Československa*, Ed.: Ryšavý, T., Prague, Československá demografická společnost, 135–143.

Kladivo, P., Roubínek, P., Opravil, Z. and Nesvadbová, M. 2015. Suburbanization and local governance-positive and negative forms: Olomouc case study. *Bulletin of Geography. Socio-economic Series* 27. (27): 95–107. DOI: http://dx.doi.org/10.1515/bog-2015-0007

Kok, H. and Kovács, Z. 1999. The process of suburbanisation in the agglomeration of Budapest. *Netherlands Journal of Housing and the Built Environment* 14. (2): 119–141.

Kroll, F., Müller, F., Haase, D. and Fohrer, N. 2012. Rural-urban gradient analysis of ecosystem service supply and demand dynamics. *Land Use Policy* 29. (3): 521–535. DOI: https://doi.org/10.1016/j.landusepol.2011.07.008

Kubeš, J. (ed.) 2009. *Urbánní geografie Českých Budějovic a Českobudějovické aglomerace I.* (Urban Geography of the city of České Budějovice and the Agglomeration of České Budějovice I). Banská Bystrica, Univerzita Mateja Bela v Banskej Bystrici.

Kubeš, J. 2015a. Analysis of regulation of residential suburbanisation in hinterland of post-socialist 'one hundred thousands' city of České Budějovice. *Bulletin of Geography, Socio-economic Series* 27. (27): 109–131. DOI: http://dx.doi.org/10.1515/bog-2015-0008

Kubeš, J. 2015b. Suburbia a typy suburbií v zázemí většího města – Českých Budějovic (Suburbs and types of suburbs in the hinterland of a larger town – the town of České Budějovice). *Regionální rozvoj mezi teorií a praxí* 2015. (2): 1–10.

Leetmaa, K. and Tammaru, T. 2007. Suburbanization in countries in transition: destination of suburbanizers in the Tallinn Metropolitan Area. *Geografiska Annaler: Series B, Human Geography* 89. (2): 127–146. DOI: https://doi.org/10.1111/j.1468-0467.2007.00244.x

Leetmaa, K., Brade, I., Anniste, K. and Nuga, M. 2012. Socialist summer-home settlements in post-socialist suburbanisation. *Urban Studies* 49. (1): 3–21. DOI: https://doi.org/10.1177/0042098010397399

Logan, J.R. and Golden, R.M. 1986. Suburbs and satellites: Two decades of change. *American Sociological Review* 51. (3): 430–437.

Makhrova, A.G., Nefedova, T.G. and Pallot, J. 2016. The specifics and spatial structure of circular migration in Russia. *Eurasian Geography and Economics* 57. (6): 802–818. DOI: https://doi.org/10.1080/15387216.2016.1274663

Mantey, D. and Sudra, P. 2018. Types of suburbs in post-socialist Poland and their potential for creating public spaces. *Cities* (in press). DOI: https://doi.org/10.1016/j.cities.2018.11.001

Marcińczak, S. 2012. The evolution of spatial patterns of residential segregation in Central European cities: The Łódź Functional Urban Region from mature socialism to mature post-socialism. *Cities* 29. (5): 300–309. DOI: https://doi.org/10.1016/j.cities.2011.08.008

Matlovič, R. and Sedláková, A. 2007. The impact of suburbanization in the hinterland of Prešov (Slovakia). *Moravian Geographical Reports* 15. (2): 22–31.

Mikelbank, B.A. 2004. A typology of U.S. suburban places. *Housing Policy Debate* 15. (4): 935–964. DOI: https://doi.org/10.1080/10511482.2004.9521527

Montagné Villette, S. and Hardill, I. 2007. Spatial peripheries, social peripheries: reflections on the "suburbs" of Paris. *International Journal of Sociology and Social Policy* 27. (2): 52–64. DOI: https://doi.org/10.1108/01443330710722751

Motte-Baumvol, B., Massot, M.H. and Byrd, A.M. 2010. Escaping car dependence in the outer suburbs of Paris. *Urban Studies* 47. (3): 604–619. DOI: https://doi.org/10.1177/0042098009349773

Musil, J. and Ryšavý, Z. 1983. Urban and regional processes under capitalism and socialism: a case study from Czechoslovakia. *International Journal of Urban and Regional Research* 7. (4): 495–527.

Novotný, L. 2012. Migrácia a prirodzený pohyb ako komponenty rastu obyvateľstva vo funkčnom mestskom regióne Košice (Migration and natural movement of the population as a component of population growth in the functional city region of Košice). *Geographia Cassoviensis* 4. (2): 152–164.

Nuga, M., Metspalu, P. and Leetmaa, K. 2015. Planning post-summurbia: from pragmatism to collaboration? *Moravian Geographical Reports* 23. (4): 36–46. DOI: https://doi.org/10.1515/mgr-2015-0023 10.1515/mgr-2015-0023

Nuissl, N. and Rink, D. 2005. The 'production' of urban sprawl in east Germany as a phenomenon of post-socialist transformation. *Cities* 22. (2): 123–134. DOI: https://doi.org/10.1016/j.cities.2005.01.002

Orfield, M. 2002. *American Metropolitics: The new suburban reality*. Washington, Brookings Institution Press.

Ott, T. 2001. From concentration to de-concentration – migration patterns in the post-socialist city. *Cities* 18. (6): 403–412. DOI: https://doi.org/10.1016/S0264-2751(01)00032-4

Ouředníček, M. 2003. The suburbanisation of Prague. *Sociologický časopis/Czech Sociological Review* 39. (2): 235–253.

Ouředníček, M. 2007. Differential suburban development in the Prague urban region. *Geografiska Annaler: Series B, Human Geography* 89. (2):

111–126. DOI: https://doi.org/10.1111/j.1468-0467.2007.00243.x

Palang, H. and Peil, T. 2010. Mapping future through the study of the past and present: Estonian suburbia. *Futures* 42. (7): 700–710. DOI: https://doi.org/10.1016/j.futures.2010.04.007

Petrova, S., Posová, D., House, A. and Sýkora, L. 2013. Discursive framings of low carbon urban transitions: the contested geographies of 'satellite settlements' in the Czech Republic. *Urban Studies* 50. (7): 1439–1455. DOI: https://doi.org/10.1177/0042098013480964

Repaská, G., Vilinová, K. and Šolcová, L. 2017. Trends in development of residential areas in suburban zone of the city of Nitra (Slovakia). *European Countryside* 9. (2): 287–301. DOI: https://doi.org/10.1515/euco-2017-0018

Roose, A., Kull, A., Gauk, M. and Tali, T. 2013. Land use policy shocks in the post-communist urban fringe: A case study of Estonia. *Land Use Policy* 30. (1): 76–83. DOI: https://doi.org/10.1016/j.landusepol.2012.02.008

Špačková, P., Ouředníček, M. and Novák, J. 2016. Zóny rezidenční suburbanizace 2013 (Zones of residential suburbanisation 2013). In *atlasobyvatelstva.cz*, Eds.: URRlab team, Prague, Faculty of Science of Charles University in Prague.

Spilková, J. and Perlín, R. 2010. Czech physical planning at the crossroads: towards the regulation of large-scale retail developments? *Environment and Planning C: Government and Policy* 28. (2): 290–303. DOI: http://dx.doi.org/10.1068/c08116

Spilková, J. and Šefrna, L. 2010. Uncoordinated new retail development and its impact on land use and soils: a pilot study on the urban fringe of Prague, Czech Republic. *Landscape and Urban Planning* 94. (2): 141–148. DOI: http://dx.doi.org/10.1016/j.landurbplan.2009.09.001

Stanilov, K. and Sýkora, L. 2012. Planning, markets, and patterns of residential growth in metropolitan Prague. *Journal of Architectural and Planning Research* 29. (4): 278–291. www.jstor.org/stable/43030982

Šveda, M., Madajová, M. and Podolák, P. 2016. Behind the differentiation of suburban development in the hinterland of Bratislava, Slovakia. *Sociologický časopis/Czech Sociological Review* 52. (6): 893–925.

Sýkora, L. and Ouředníček, M. 2007. Sprawling post-communist metropolis: commercial and residential suburbanisation in Prague and Brno, the Czech Republic. In *Employment de-concentration in European Metropolitan Areas: market forces versus planning regulation*s, Eds.: Razin, E., Dijst, M. and Vázquez, C., Dordrecht, Springer, 209–233.

Sýkora, L. and Stanilov, K. 2014. The challenge of post-socialist suburbanization. In *Confronting Suburbanisation: Urban Decentralization in Post-Socialist Central and Eastern Europe*, Eds.: Stanilov, K. and Sýkora, L., Chichester, Wiley-Blackwell, 1–32.

Szczepańska, A. and Senetra, A. 2012. Migrations of city dwellers to suburban areas – the example of the city of Olsztyn. *Bulletin of Geography. Socio-economic Series* 18. 117–124. DOI: http://dx.doi.org/10.1515/v10089-012-0024-2

Szelényi, I. 1983. *Urban inequalities under state socialism.* New York, Oxford University Press.

Tammaru, T. 2001. Suburban growth and suburbanisation under central planning: The case of Soviet Estonia. *Urban Studies*, 38. (8): 1341–1357. DOI: https://doi.org/10.1080/00420980120061061

Tammaru, T. 2005. Suburbanisation, employment change, and commuting in the Tallinn metropolitan area. *Environment and Planning A* 37. (9): 1669–1687. DOI: https://doi.org/10.1068/a37118

Tammaru, T., Leetmaa, K., Silm, S. and Ahas, R. 2009. Temporal and spatial dynamics of the new residential areas around Tallinn. *European Planning Studies* 17. (3): 423–439. DOI: https://doi.org/10.1080/09654310802618077

Tanaś, J. 2013. Differentiation of suburbanization processes in Poznań agglomeration. *International Journal of Academic Research* 5. (3): 369–366. DOI: https://doi.org/10.2478/remav-2013-0030

Vágner, J., Müller, D.K. and Fialová, D. 2011. Second home tourism in light of the historical-political and socio-geographical development of Czechia and Sweden. *Geografie* 116. (2): 191–210.

Vaughan, L., Griffiths, S., Haklay, M. and Jones, C.K.E. 2009. Do the suburbs exist? Discovering complexity and specificity in suburban built form. *Transactions of the Institute of British Geographers* 34. (4): 475–488. https://www.jstor.org/stable/40270732

Vobecká, J. and Piguet, V. 2012. Fertility, natural growth, and migration in the Czech Republic: an urban-suburban-rural gradient analysis of long-term trends and recent reversals. *Population, Space and Place* 18. (3): 225–240. DOI: https://doi.org/10.1002/psp.698

Wolny, A. and Źróbek, R. 2017. The interdependence between suburban enclaves and the road network in the development process: A case study in Poland. *Geographia Polonica* 90. (2): 41–57. DOI: https://doi.org/10.7163/GPol.0086

Zębik, G. 2011. Typology of suburban communities in Poland. *Bulletin of Geography. Socio-economic series* 16. 173–188. DOI: https://doi.org/10.2478/v10089-011-0021-x

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"Sharing" tourism as an opportunity for territorial regeneration: the case of Iseo Lake, Italy

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Abstract

The spread of sharing economics platforms in the world of travels has highlighted the little known phenomenon of the rental of houses and apartments with a non-enterprise management. These accommodations in Italy do not require any guest registration or start-up notification, but the use of websites such as Airbnb has led to a heated debate among the actors operating in the travel and tourism industry. In fact, the regulatory vacuum and the easy-to-use websites would help circumvent the rules in order to "hide away" some business activities. Based on these assumptions, this paper analyses the case of Iseo Lake in the Northern Italy, pointing out the discussions about this new trend in travels and involving not only economic and legal aspects, but also social issues that cannot be ignored. The paper presents "sharing tourism" as an opportunity for territorial regeneration in destinations characterized by the presence of few hotel facilities, but also of many empty apartments.

Keywords: sharing economy, hidden tourism, alternative hospitality, renting houses, peer-to-peer accommodation, Airbnb, territorial regeneration, Iseo Lake

Introduction

The recent development of *sharing economy*[2] in tourism has led to an increased rental of holiday houses on the Internet (Zervas, G. *et al.* 2017). This fact reflects the need of the owners to occasionally supplement their income and, at the same time, stresses a progressive change of tourism habits and tourists, who prefer short and recurring stays throughout the year directly booked from the Internet, allowing them to authentically experience the place by lodging in facilities managed by locals. With reference to the first point, Karlsson, L. and Dolnicar, S. (2016) conducted an online survey among the Airbnb hosts from Australia to gain insight into what drives the supply side of the peer-to-peer accommodation networks, involving all the national active hosts who receive the monthly newsletter. The result of the questionnaires shows that income (82%) is main reason for hosting people, followed by social interaction (31%) and sharing (14%) (Karlsson, L. and Dolnicar, S. 2016). A regards the second point, new low-cost flights also changed the way in which we travel, as well as the dissemination of new ideas at global level, including, for example, sustainable tourism or the *Slowfood* movement (www.slowfood.com). In this context, holiday houses represent an informal type of accommodation which has recently raised a great interest, reflecting the latest market tendencies such as the growth of holiday farms, guesthouses, shelters and B&B. Specifically, the paper fo-

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[2] Sharing economy is generally intended as a new economic model. It refers to forms of exchange facilitated through online platforms, encompassing a diversity of for-profit and non-profit activities that are broadly aimed at granting open access to under-utilized resources through what is called "sharing" (Richardson, L. 2015). In addition to vacation rentals, the sharing economy has extended to urban mobility (Bálint, D. and Trócsányi, A. 2017).

cuses on the situation in Lombardy with reference to holiday houses managed in a non-enterprise form only (maximum 3 housing units). In particular, the availability of less than three apartments are considered by the Italian legislation a non-enterprise form, so neither guest registration nor start-up announcement are required. Nowadays this is set, among the business operators of the field, as a major point of discussion seeing the extent at which this lack of regulation would allow, through websites like Airbnb, the law to be circumvented and the actual business activities to be "hidden away".

Now, however, it is necessary to explain how the tourism law works in Italy. On 5 May 2011, the Italian Council of Ministries issued the "Tourism Code" to regulate the tourism sector at State level with the purpose of adapting the existing obligations under the international and EU law. Notwithstanding, at regional level, the Constitution itself (art. 117) assigns exclusive legislative powers to Regions and autonomous Provinces (Trento and Bolzano). Therefore, each Italian Region has its own tourism laws, while, according to the basic principle of subsidiarity, all of them follow the principles set out by the EU and national Italian legislation (http://iftta.org/italy). The Region of Lombardy is an interesting case study, because it has issued a new law that changes the approach to tourist rentals. The old Lombardy Regional Law on Tourism (no. 15 of 16 July 2007) considered holiday houses (*case e appartamenti per vacanze – CAV*) managed in an enterprise form when the subject had the availability, even temporary, of a minimum of three apartments located in the same municipal territory (art. 43), excluding the cases with less than three apartments (http://normelombardia.consiglio.regione.lombardia.it). In 2015, the Region approved a new Tourism Law (n. 27/2015) which, for the first time in Italy, tried to legalize the situation of holiday houses managed in a non-enterprise way, defining new procedures in order to hinder tax evasion and unfair competition.

Although this legislation might seem positive at first sight, it is necessary to highlight the complications that this law imposes to those who fairly rent their apartments. In this regard, a discussion is proposed about the consequences arising from the application of this legislation, examining the area of Iseo Lake in Lombardy. This paper stresses how the implementation of the new law cannot be exempted from the analysis of the territorial context, if it aims at promoting the development of a sustainable tourism able to prevent the natural depopulation of small areas. If it is true indeed that spread of the Internet has encouraged new accommodation systems, simultaneously new procedures may disadvantage aged proprietors, most likely found in marginal contexts such as peripheral areas, far from the big cities. In the worst case scenario, such situation may culminate with the dismissal of those accommodations, thus affecting the local development as a whole. To avoid these consequences, the involvement of authorities, tourism associations and citizens, should be promoted to support the creation of a "scattered hospitality". This is defined as a form of tourism characterised by the dispersal of accommodation capacities across an area, based on a network of vocational rentals and holiday houses managed by a central institution that, in this case, may help owners with bureaucratic fulfilments. Scattered tourism should offer new possibilities for revitalising rural areas and include decaying structures in commercial activity, also obtaining funds for their renovation (Burini, F. 2011; Irimiás, A. and Michalkó, G. 2013). For example, in Italy it is worth mentioning the *albergo diffuso* as defined by Dall'Ara, G. (2015) (www.albergodiffuso.com). This approach can encourage an integrated territory promotion which may turn unused properties into an opportunity.

Holiday houses: definition and diffusion

Holiday houses reached their peak in Italy in the 1970's and 1980's, although nowadays such phenomenon has reached even higher levels thanks to websites able to connect potential guests with the owners of holiday

houses, like Airbnb, Booking, Wimdu or HomeAway. Settling down in private accommodations grants an independent management to tourists and meets, at the same time, the economic needs of families, also enabling them to "live like locals" (Romita, T. 2010; Oskam, J. and Boswijk, A. 2016). From a legal point of view, the Italian Tourism Code (art. 53 of Legislative Decree 79/2011) defines holiday houses as those "exclusively rented for tourist purposes, located anywhere", while the Civil Code (art. 1571 *et seq.*) requires a written and notified agreement only for rentals longer than 30 days. In case of accommodation shorter than 30 days, neither agreements nor fees are required, leaving a legislative void that makes the quantification of this phenomenon much more complicated[3]. Sure enough, the official surveys carried out by the Italian National Institute of Statistics (ISTAT) take into consideration only "classed" facilities (excluding non-enterprise holiday rental) for the estimate of the tourist flow. Considering that this information is only partial, an in-depth analysis is required in order to grasp the whole phenomenon.

According to the ISTAT "Trips and Holidays survey" (*Viaggi e Vacanze*)[4], in 2017 there were 291 million overnight stays by Italian tourists in Italy, 98 million of whom chose collective tourism facilities (hotels, specialised collective facilities, other kinds of collective facilities[5]). The remaining 193 million people preferred private accommodations, like rented houses/rooms including B&Bs, personally owned home/timeshare properties, houses of relatives or friends or other private accommodations (ISTAT 2017a). Comparing these data with those collected by Region and Province administrations through official notifications and analysed by the ISTAT 210 million of overnight stays is reached in 2017, 139 million of which were spent in hotels and hotel-tourism residences, while 71 million in other collective accommodations. In particular, more than 18 million people stayed in (rented) holiday dwellings entrepreneurially managed, and more than 3 million people opted for B&Bs (ISTAT 2017b). Although these data were collected and identified with different methodologies, this comparison allows us to assume the ability of the accommodation facilities (where 210 million overnight stays were spent) to attract the national tourist flow (291 million of overnight stays), amounting to 72 per cent.

Other useful data are provided by the Bank of Italy and were collected through a sample survey at the incoming frontiers of Italy[6]. In 2017, about 368 million foreigner tourists were estimated to come to Italy for an overnight stay (Bank of Italy 2017), of whom 184 million chose a hotel, holiday village, B&B or holiday farm, while 52 million

[3] A new tax regime for rentals shorter than 30 days was introduced in Italy only in 2007. It imposes the fulfilment of some tax obligations on those persons who carry out real estate brokerage activities (including telematic portals), such as the withdrawal of the 21 per cent of the income earned by the owners of the accommodation as a flat rate tax, in the event that the broker also takes care of the payment of the accommodation or the tourist tax by the tourist (article 4 and law 96/2017 of Legislative Decree 50/2017).

[4] The survey is conducted on a monthly basis with CAPI (Computer Assisted Personal Interview) technique, on a theoretical national sample of 28,000 households (7,000 households per quarter). Since 2014 the survey has been included into the household budget survey (http://dati.istat.it).

[5] The term '*Hotels*' includes hotels/motels/boarding houses, religious institutions; '*Specialised collective facilities*' are residences for physical/beauty treatment, volunteer work camps and holiday camps, accommodations on means of public transport (couchettes, sleeping cars, etc.), congress and conference centres, holiday farms; '*Other kinds of collective facilities*' means holiday villages, campsites, marinas and other collective facilities.

[6] Since 1996 the Bank of Italy has been conducting a comprehensive survey on international tourism for the purpose of calculating the travel item of Italy's monthly balance of payments. Data are collected based on 120,000 interviews at the border points (nearly 70 border points among the most representative ones in terms of flows) with face-to-face interviews using a structured questionnaire. The interviews are conducted at the end of the trip in order to capture the expenditure actually incurred and not the potential or planned one (Survey on International Tourism. Methods and Sources: Methodological Notes. www.bancaditalia.it).

preferred a rented vacation house, more than 62 million opted for another type or facility, nearly 70 million stayed in friends and relatives' houses as guests (VFR). Meanwhile, according to the ISTAT data, 210 million overnight stays by foreigners were recorded both in hotels and in other collective accommodations. Excluding VFRs, there is a big gap between the data provided by the ISTAT and the Bank of Italy, amounting to nearly 88 million. Subject to their pure representative purposes, these statistics show the presence of about 30 per cent of national tourists and nearly 30 per cent of foreign tourists outside the official licensed accommodations, thus assuming that some of them may have benefited from alternative accommodations, including non-enterprise forms of room rentals. In conclusion, the phenomenon of the non-enterprise tourist rental is not negligible, especially considering that the Internet not only favoured the spread of this new type of accommodation but also simplified its procedures and advertisement. This has opened up a new world unknown until now, which needs an in-depth analysis and further research, beyond the financial and legal matters, to examine its territorial effects.

Airbnb: between sharing economy and shadow economy

Airbnb is one of those websites deriving from the *sharing economy* which gave a strong impulse to the short-term rental market. Through a free registration, it connects people who have an apartment or a room for rent with those who are looking for temporary accommodations. Service fee amounts to 6 to 12 per cent for guests, and 3 per cent for the landlord, while prices, competitive compared to hotels, are set by users depending on supply and demand. Besides this, Airbnb offers a series of additional services to their users: verified advertisements, payment brokerage, a reciprocity mechanism based on host and guest reputation obtained through reviews. Airbnb's operative system allows only those who offered hospitality and enjoyed it to post first-hand reviews. This helps avoid fake reviews from fake hosts or guests. Furthermore, the organization offers specific services for business travellers (www.airbnb.com). Moreover, Airbnb has recently expanded its supply, going beyond simple home sharing and allowing users to book "experiences" offered by the hosts to get in touch with the local community through cooking classes, guided tours, surf classes and other adventures. Eventually, the "Guidebooks" section offers a collection of all the best places in every city, as suggested by the Airbnb hosts, to discover hidden and one-of-a-kind places.

Despite its relatively recent establishment, in 2008, this new business reality had spread at a quick pace, boasting listings in around 81,000 cities in more than 191 Countries (www.airbnb.com). Italy has gained the third place in the global market, shifting from 52 listings in 2008 to 397,314 at the end of August 2018, with a great impact on the entire national territory at different levels and an exponential growth that shows no signs of stopping (174,528 more houses compared to August 2016 with an increase by 78.3%) (Federalberghi 2018). In 2017, in Italy there were around 104,000 licensed holiday houses and 19,000 B&Bs (ISTAT 2017c).

Since the Airbnb system does not help verify which and how many structures are licensed, the comparison between the official data and the number of listings on the website is quite difficult, however, it is possible to highlight the significant extent of this phenomenon size. As already stated, hotel companies have recently criticized Airbnb and other similar websites, accusing them of both encouraging underground profits and supporting *shadow economy,* together with an unfair competition to the detriment of legally verified tourist structures. In particular, they accuse Airbnb of operating in the interstitial areas of law relying on new and fundamentally different issues not included in statutes and regulations (Kaplant, R.A. and Nadlert, M.L. 2015).

Internationally speaking, it is worth mentioning the case of Barcelona, Berlin, and San Francisco, where management had "declared war" to Airbnb's illegal rents through heavy fines applied to all the unlicensed apartments (Kendal, M. 2016; Oltermann, B. 2016; Burger, S. 2017). In Italy, in 2017 Federalberghi (the Italian Hotel Association) entrusted the Incipit Consulting society with the monitoring of "hidden" tourism, with a special focus on Airbnb (Rátz, T. *et al*. 2015; Minuti, M.S. and Incipit Consulting 2016; Federalberghi 2018). In 2016, Federalberghi estimated 111.4 million tourists located in private houses. Among them, 73.8 million stayed at unlicensed private accommodations, generating a sales volume of 2.4 billion EUR, with 112 million EUR of VAT tax evasion, tourist fees equal to 57 million EUR evaded, 73,000 illegal workers involved who could be turned into regular employees (Intervention recap from Giuseppe Roscioli, Federalberghi vicarial vice-president at the Chamber of Deputies of the Italian Parliament, 2 May 2016). To face this situation, Airbnb has recently defined a *community compact* in which it declares that it treats every city personally and ensures the payment of its fair share of accommodation and tourist taxes (www.airbnbcitizen.com). Moreover, in the last two years, Airbnb had signed many agreements with cities for the payment of tourist tax. However, the effect caused by this new type of tourism goes well beyond tax or economy, but includes social and territorial issues. For example, many citizens have risen against the increase in rents caused by the presence of Airbnb in urban centres, in spite of the company attempts to promote a responsible home sharing.

From a tourism planning point of view, the lack of official data regarding the measure of the phenomenon makes this issue even more complex, because local administrations base their researches upon official statistic data. Furthermore, the spread of these operative systems and the rental of empty houses could turn out to be favourable for the revitalisation and development of smaller towns, promoting new forms of tourism, in accordance with s-Low philosophy, promoting at the same time a territorial regeneration.

Arts and new forms of "micro-accommodation": Iseo Lake towards a new tourist development

Iseo Lake is the smallest lake at the Alpine foothills (after Como, Garda and Maggiore lakes). Almost equally divided between the Provinces of Bergamo and Brescia, the Lake is characterized by the presence of the largest natural lake island in Italy as well as the of the highest lake island in Europe: Monte Isola, together with two small islands of Loreto and San Paolo (www.visitlakeiseo.info/en/). Fed by the Oglio river, Iseo Lake is located between the Val Camonica to the North (a UNESCO site since 1979 thanks to its prehistoric petroglyphs, http://whc.unesco.org/en/list/94) and Franciacorta to the South (famous for the production of wine of the same name, www.franciacorta.net/en/).

Lately, it has earned huge global fame thanks to Christo's land art work *The Floating Piers* which, from 18 June to 3 July 2016, required the installation of three floating piers, covered in a shimmering yellow fabric, that connected the town of Sulzano, on the bank of Brescia, with Monte Isola and then again with the Island of San Paolo, reaching a length of 4.5 kilometres (www.thefloatingpiers.com). This structure, built over the water, aimed at allowing visitors to literally "walk on water", besides giving a new perspective to the lake area. Such event brought to Iseo Lake, in 16 days only, around one million and a half visitors, decisively boosting its tourism promotion. This opportunity strengthens the so-called G16, an association gathering 16 coast municipalities lead by Lovere, offering, for the very first time, an integrated lake tourism promotion.

Thanks to *The Floating Piers,* moreover, the municipalities received a support from the Lombardy's regional central administration in the form of a loan amounting to 300 million EUR. This money will be invested in communication sharing and the optimisa-

tion of tourist information points, as well as for the promotion of a Young Artists Factory which assigns areas, natural locations and abandoned buildings to young artists where they can organise workshops and set up temporary art studios, thus appointing the lake as a site of art preserving Christo's legacy. Furthermore, the G16 association, along with Lombardy Region, agreed on a new territorial enhancement plan. Tourism, therefore, is nowadays the core sector in Iseo Lake, but it is essential for this area to be equipped with a network of reception facilities, in order to guarantee its development. Considering the inadequate number of hotels, the lake area is full of B&Bs and renting locations which, during *The Floating Piers* days, offered a crucial support to the traditional accommodations. This kind of locally managed "human-sized" hospitality could represent a distinctive feature of the lake territory, also involving empty houses within the tourism chain, as will be explained below.

Airbnb and holidays room-for-rent on Iseo Lake

The Iseo Lake accommodation system is characterized by a restricted number of hotels, only 46 among the 16 above-mentioned municipalities, against a high number of B&Bs and vacation rentals, respectively 52 and 158[7] (Province of Bergamo, Observatory of Tourism 08/31/2016; Province of Brescia, Observatory of Tourism, 06/30/2016). Particularly, in 2015, the holiday rooms for rent were just 17, exponentially increasing within one year, presumably thanks to *The Floating Piers* event. The vacation rentals were concentrated around the Brescia lake side (*Figure 1),* within the municipalities of Iseo and Marone at the edge of the restricted area set during the event around Sulzano, where the floating pier started, and Sale Marasino. Bound to their local initiatives, the favourable position and accessibility of these two sites have probably stimulated such proliferation of non-hotel accommodation facilities.

Likewise, in Monte Isola, the core of the event, the peak of the vacation rental was

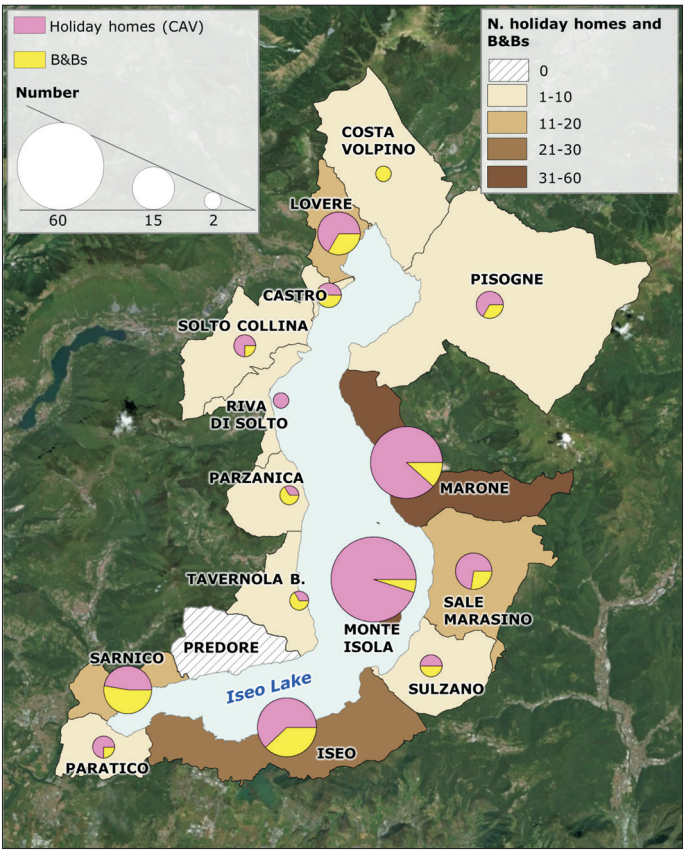


Fig. 1. Territorial distribution of licensed holiday homes and B&Bs within the G16 municipalities. *Data sources*: Province of Bergamo, Observatory of Tourism 08/31/2016; Province of Brescia, Observatory of Tourism, 06/30/2016. Data processed by the author.

[7] Moreover, there is a hostel in Lovere, and 19 camping sites around the Iseo area.

reached among the first six months of 2016, going from 3 up to 57. In Bergamo lake side, those numbers have diminished, although a considerable increase in the vacation rental is detectable, going from 7 up to 28 in those nine municipalities, while the B&B data remained unchanged (Province of Bergamo, Observatory of Tourism 08/31/2016). Regarding Airbnb (*Figure 2*), the advertisements posted by the end of September 2016 were 289, 74 of which concerned rooms for rent, while the remaining 215 referred to entire proprieties.

Analysing the hosts' usernames, a very limited number of people managing more than 3 housing units for rent can be observed, around 3 or 4 cases, showing how such activity is still just a supplement of income. Although no detailed data are available to verify the conformity between licensed accommodation facilities and those mentioned on the website, the difference among the number of listings (289) and that of licensed B&Bs and vacation rentals (210) helps approximately estimate a 30 per cent supremacy of alternative accommodations. Furthermore, the website does not provide any subscription archive, therefore it is impossible to make comparisons between 2015 and 2016, however, the reference to *The Floating Piers* as part of the title of many announcements suggests, even in this case, the extent of the positive impulse that it gave to tourism as well. Eventually, also as regards Airbnb, there's a remarkable concentration of listings coming from the Brescia side of the lake, compared to the few accommodations on Bergamo side.

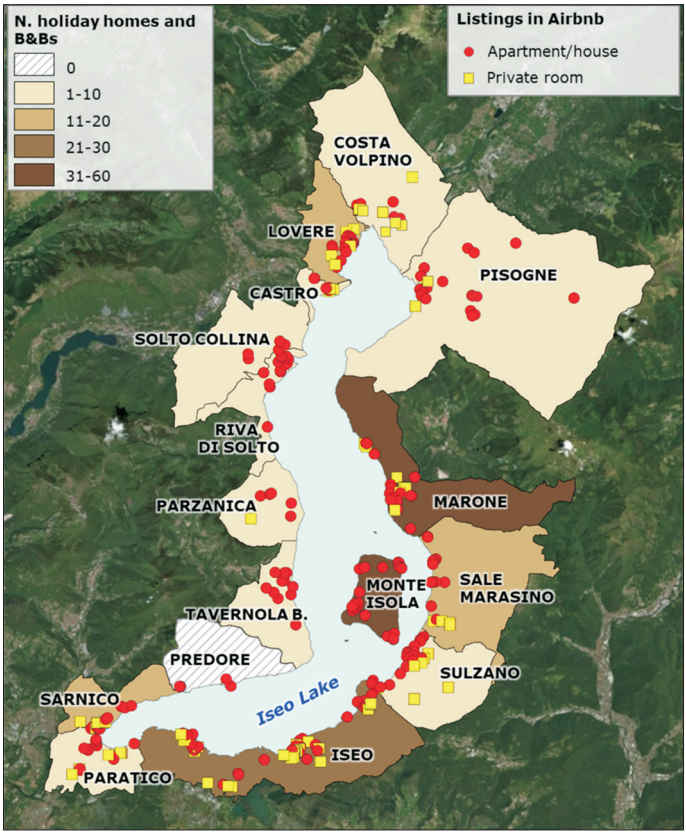


Fig. 2. Spread of Airbnb listings and number of licensed Holiday houses and B&Bs within the G16 municipalities. *Data sources:* Province of Bergamo, Observatory of Tourism 08/31/2016; Province of Brescia, Observatory of Tourism, 06/30/2016; www.airbnb.com, Sept. 2016. Data processed by the author.

Through the analysis of the circumstances from each province, it is possible to highlight how the number of listings posted is higher than the amount of the actual licensed vacation rentals and B&Bs, except for Monte Isola and Marone, where the number of official structures, compared to Airbnb rentals, has respectively doubled and tripled. These data suggest the existence and persistence of a major tradition concerning touristic accommodation, featuring the traditional word-of-mouth communication channels, although the lack

of data about it cannot confirm this assumption. Moreover, these data show how not all the licenced structures post announcements on the website. Generally, a comparison between the official data with the Airbnb ones helps point out what tends to be the case of touristic locations, stressing the potential of this new accommodation facility in places, like Iseo Lake, where very few hotel accommodations are situated.

From holiday house rentals to a scattered hospitality

Until now, while examining the situation of Iseo Lake, only those houses which are already part of the tourism market, officially or not, had been taken into account. However, based on the ISTAT data collected during the last census 2011, it is possible to notice the existence of numerous "unoccupied houses" within the G16 municipalities. Specifically, this term means an aggregate including vacation houses, lodgings occupied by non-resident people (like off-campus students, off-site workers) and empty residences. Since 2001, the census has not mentioned the building intended use anymore, making no reference to "vacation rentals" unlike the previous census, making it impossible to quantify rent-out buildings for tourist purposes.

This phenomenon affects the whole territory, as shown in *Figure 3*, and spreads differently within the district territories. The municipali-

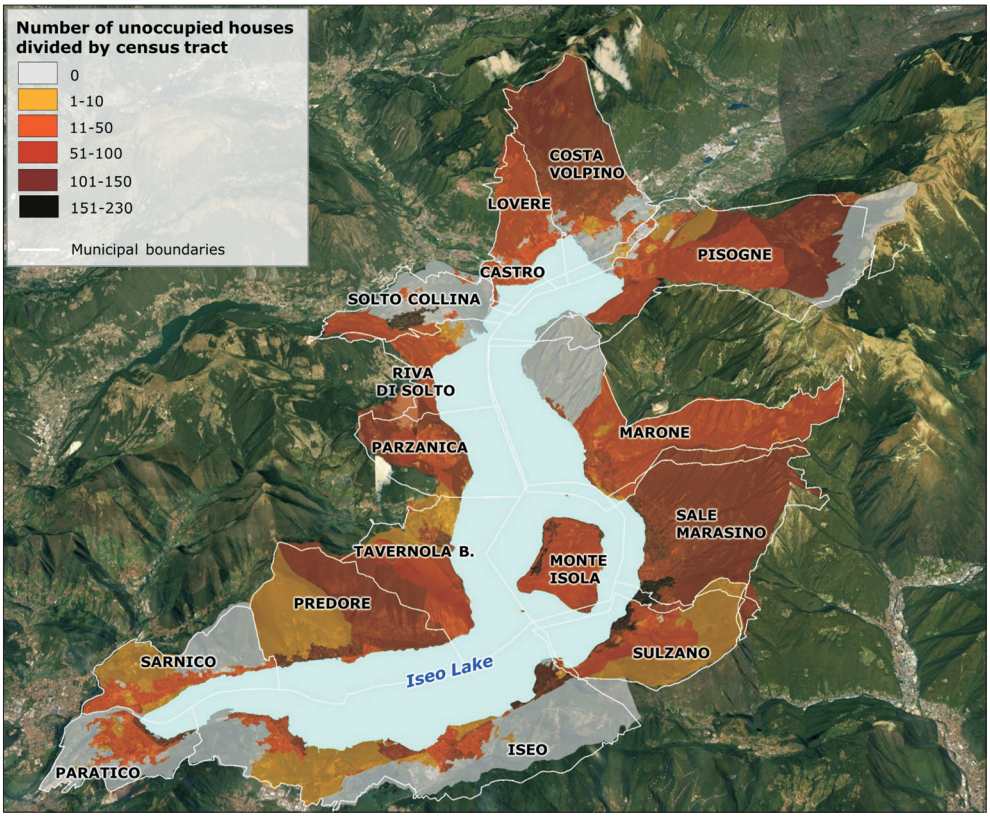


Fig. 3. Number of unoccupied houses broken down by census section within G16 municipalities. *Data source:* ISTAT Population and housing census, 2011. Data processed by the author.

ties in the lower part of the lake are characterized by a concentration of unoccupied buildings especially in the historical centres and lakeshore. On the contrary, the municipalities in the upper part of the lake, particularly Costa Volpino and Pisogne, show a higher number of unoccupied mountain areas. Finally, in Sale Marasino unoccupied residences are copiously distributed across the whole territory.

Considering these data, out of a total of 33,700 residences notified by the ISTAT the unoccupied ones account for about 22 per cent of the whole (the buildings occupied at least by one person are 26,117, while the unoccupied ones are 7,589) (ISTAT 2011). Although being in line with the national average, which is 23 per cent[8], these data are relevant with special reference to the territorial distribution with a greater impact on mountain areas and historical centres, revealing a progressive abandonment of those areas towards more accessible places. As a result, the number of residents has decreased, employment in seasonal-only facilities, service reduction, and consequently, a drop of interest (Macchiavelli, A. 2011). The under-use of buildings, therefore, represents a problem for those places, but at the same time could lead to new types of tourism. As regards Iseo Lake, which became famous worldwide thanks to *The Floating Piers* event, the official ISTAT and Airbnb data show the proliferation of new reception accommodations, managed either entrepreneurially or not, supporting hotels during those 16 "Christo-dedicated" days and allowing them to face a huge accommodation demand. In view of the future promotion of sustainable tourism, the development of this new kind of "human-sized" accommodation managed by locals could become a distinctive trait of the lake territory.

[8] According to Italian Association of Private Construction Contractors (ANCE), the Italian housing stock mainly consists of lodgings occupied by residents, equal to 24 million units (77.3% of the total), while 7 million units are unoccupied or occupied by non-resident people (ANCE 2015).

From new forms of "micro-accommodation" to territorial regeneration: inspiring experiences

In the 1980s, the concept of *albergo diffuso* was born for the first time to support the need to recover abandoned houses (and subsequently restructured) following the earthquake in the Friuli-Venezia Giulia region (Italy) in 1976. The *albergo diffuso* (AD), or "scattered hotel", is a form of hospitality characterised by host customers in the accommodations created inside and around the existing houses in mostly rural contexts, with a centralized reception and provided with all the assistance services that hotels should have (Dall'Ara, G. 2015).

According to a research by JFC consulting, this is one of the accommodation types preferred by the visitors to the villages (19.2% versus 22.9% in farm holiday and 21.2% in B&Bs), because it allows tourists to live in contact with residents and their traditions, emphasizing an ever-increasing search for authenticity on the tourists (JFC 2016).

In fact, the AD offers visitors the opportunity of "living in the area", by taking part in the social life of the village, and should prevent the depopulation of small rural towns. In Italy, there are about one hundred ADs and this model has been reproduced in several Countries worldwide, like Spain, Switzerland, Croatia, Germany, San Marino, Japan and China.

A case of positive scattered hospitality model is the historical village of Ornica, situated in northern Italy, in a valley of the Orobic Alps in the province of Bergamo. This initiative arose from the synergy between a contractor and a local women cooperative, *Donne di montagna* (www.albergodiffusoornica.it). The village was at risk of extinction and had only 160 inhabitants, while today, thanks to the involvement of the inhabitants, has tripled the presences in summer and is effective all year long[9]. In addition to hospi-

[9] Val Brembana is the Lombard area that has suffered the greatest depopulation in the last 30 years and is now included in the PADIMA (Policies Against Depopulation In Mountain Areas) European project,

tality, the village offers numerous experiences such as trekking, tastings, sheep shearing, cheese production, haymaking, harvesting of wild herbs, etc. (Gandolfi, A. 2017). At the same time, in recent years, Airbnb has shown a growing interest in rural areas and villages, funding numerous projects for the empowerment of small communities through the activation of tourist experiences.

Civita di Bagnoregio is a small village in the Province of Viterbo (Lazio) with only 6 residents in wintertime[10]. Here Airbnb, together with several partners and in cooperation with the municipality of Civita, has contributed to the restoration of *Casa d'Artista* (Home of the Artist), a historically significant building in the town, making it the first public listing available on the platform, whose profits will be used to fund cultural projects in Civita. In 2017, the Italian Villages Campaign[11] was launched and sponsored by The National Association of Italian Municipalities (ANCI) in cooperation with the Italian Ministry of Culture and Tourism (MiBACT). It promotes more than 40 villages all over the country, thus developing a nationwide marketing campaign to help promote non-urban travels. In three of these towns (Lavenone in Lombardy, Civitacampomarano in Molise and Sambuca di Sicilia in Sicily) three public projects will be redeveloped in cooperation with local communities, as happened in the pilot project in Civita.

Eventually, Airbnb launched a *Community Tourism Programme* to support innovative projects among local communities which encourage healthy tourism. In Italy, Matera has been awarded the 2019 European Capital of Culture. Several initiatives are planned to involve the local community and travellers; one of them is *Wonder Grottole*, a regeneration project regarding a small town 30 km away from Matera on the top of the Lucania hills, which has 300 inhabitants and 629 abandoned houses. Airbnb is selecting four people who will move to the small town for three months to become temporary citizens and volunteer for the local non-profit organisation called "Wonder Grottole" whose aim is to revitalize the city centre of the town. Other projects for small villages are developed in Spain, the European country with the highest number of empty houses, as well as in France, Ireland, Japan and other Countries (Airbnb 2017).

Although these projects have led to the renovation of a small number of buildings, they are still indicative of the potential offered by the Airbnb platform, as well as of the possibility of cooperating with the local administrations, with a view to regenerating small villages and reducing the concentration of tourists in the most famous locations. These opportunities could be fully exploited through the creation of a network of operators, communities and administrations working together in order to reduce the negative impacts of the spread of short-term rentals, without, however, boycotting them. Probably, all these initiatives will help Airbnb prove its ethics but at the same time allow people to use one of the most famous digital rental platforms in the world become aware of new routes through small villages, while the experience of Ornica shows that another kind of tourism is possible.

Conclusions

With the regional tourism law no. 27/2015, Lombardy tried to apply the same financial, security, communication and guest notification rules to all the hotels and other collective

while the *Donne di Montagna Cooperative* has become a case study. In 2017, the guests registered at the hotel were, excluding children's workshops, more than 300, with a cost from 30 to 65 EUR per day (Gandolfi, A. 2017).

[10] The small village is set on the top of a tuff hill that is that is progressively collapsing, therefore Civita is known as "the dying city". It is connected to the surrounding countryside by a one-kilometre bridge suspended at a height of 70 metres.

[11] The campaign was launched on the occasion of *The Year of Italian Villages 2017*, sponsored by Italian Ministry of Culture and Tourism (MiBACT) (www.turismo.beniculturali.it).

accommodations, including non-enterprise managed vacation rentals (art. 26 of regional law no. 27/2015). Today, every owner is obligated to notify both his business start-up and guest identities to his/her municipality, including occasional lodgings[12]. Besides assuring a higher supervision, such legislation should allow for a greater accuracy for the collection of data, thus providing a realistic overview of tourism in Lombardy. However, it is necessary to evaluate the complications that the new law could entail for occasional landlords. If it is true, indeed, that the spread of the Internet has encouraged the development of new accommodation systems, it is also true that the owners are often old people, especially in the uphill areas, or city residents with a second home who may find it difficult to manage their apartments. At worst, this could work as a disincentive for these places, affecting the whole local development. In order to avoid such negative consequences, in the Lake Iseo area, the setting up of an entity, possibly led by the G16 association, should be pursued with a double purpose: supervising the territory and supporting the fulfilment of the new law regulation by the owners. Moreover, the promotion of a vacation lodgings network could promote the enhancement of the tourist facilities in the Lake Iseo, bettering its quality and facilitating the employment of unoccupied houses. Such entity, in addition to the assistance to the owners both through their business first steps and through the management of tourism flow notification, should entirely encourage the vacation lodging network through the www.iseolake.info website, regularly posting a list of accommodations and providing owners with information about Airbnb and similar websites, in order to positively exploit this international showcase. This authority should also represent a reference point both for tenants who – against the payment of a yearly fee – will receive assistance, and for tourists, who will gain useful information in order to plan their own vacations.

An example of service entity of this kind can be found in another Italian Region: Trentino Alto-Adige, one of the most important tourist areas in the Alps which, in the 1970's, quickly developed this tourist apartments trend. In 2002, the Trento province administration issued the provincial law 07/2002 "Protocol of hotel and non-hotel accommodation facilities and quality promotion of touristic capacities" (art. 37bis), which imposed the touristic lodging notification to the municipality for any kind of accommodation for stays longer than 14 days staying even if not consecutive with the purpose of creating a location rent database. Moreover, a national and provincial tourist marketing society, Trentino Marketing, together with Territorial Tourism companies, activated a vacation housing enhancement project. This entailed the mapping, classification and certification of every lodge with the aim of reintegrating at least a part of those 125,000 unused sleeping accommodations into the tourist network. Thanks to a series of loans, provided by the Territorial Agreements, some of the above-mentioned apartments have been renovated to guarantee a good quality standard (Andreotti, S. *et al.* 2011).

On the basis of this, and through the aid of the new regulations in Lombardy, the G16 association may create a register reporting all the operative vacation lodgings, managed both entrepreneurially or not, followed by the mapping and classification of unoccupied houses, verifying their state and the rental agreements. Based on this information, local administrations should start a process of community involvement from those places with a high concentration of unoccupied houses, going beyond the Trentino experience to support a "participative" tourism actually starting from the renovation of those

[12] Based on art. 14 Lombardy Region, through the Regional Tourism Observatory, receives from each municipality the so-called SCIA (Verified business start-up notification) and the preventive start-up notifications of all the receptive structures (short rentals included), then posts them online (on the Regione Lombardia website) as a "unified regional list divided by typology", which is still a work in progress (rl 27/2015, art. 14).

structures. The development of this kind of "alternative" accommodations, managed by locals and close to the very nature of the place, could turn up as an opportunity for a tourist regeneration, turning the "scattered accommodation capacity" into the distinctive trait of Lake Iseo.

REFERENCES

Airbnb 2017. *Beyond cities: How Airbnb supports rural revitalization*. Available at: www.airbnbcitizen.com

ANCE 2015. *Lo stock abitativo in Italia* (The housing stock in Italy). Available at: www.ance.it/docs/docDownload.aspx?id=25011

Andreotti, S., Grigolli, P., Rigoni, E. and Sacco, F. 2011. Seconde case e appartamenti turistici, l'esperienza del Trentino (Second homes and tourist apartments, the experience of Trentino). In *Le abitazioni di vacanza nella funzione turistica territoriale. Diffusione, problematiche ed esperienze di gestione*. Ed.: Macchiavelli, A., Milano, FrancoAngeli, 41–68.

Bálint, D. and Trócsányi, A. 2017. New ways of mobility: the birth of ridesharing. A case study from Hungary. *Hungarian Geographical Bulletin* 65. (4): 391–405. Available at: https://doi.org/10.15201/hungeobull.65.4.7

Bank of Italy 2017. *Survey on Italy's International Tourism 2017*. Available at: www.bancaditalia.it (in Italian)

Burini, F. 2011. *Scattered tourism: community mapping for the promotion of eco-museums*. Paper presented at the 7th Annual International Conference on Tourism, 13–16 June 2011, Athens, Greece, ATINER.

Dall'Ara, G. 2015. *Manuale dell'Albergo Diffuso. L'idea, la gestione, il marketing dell'ospitalità diffusa* (The Albergo Diffuso Manual. The idea, the management, the marketing of scattered hospitality). Milano, FrancoAngeli.

Federalberghi 2018. *Turismo e shadow economy, tutela del consumatore, concorrenza leale ed equità fiscale al tempo del turismo 4.0* (Tourism and shadow economy, consumer protection, fair competition and fiscal equity at the tourism 4.0 time). Roma, Federalberghi. Available at: www.federalberghi.it.

Irimiás, A. and Michalkó, G. 2013. Religious tourism in Hungary – an integrative framework. *Hungarian Geographical Bulletin* 62. (2): 175–196.

ISTAT 2011. *15th Population and housing census*. Available at: http://dati-censimentopopolazione.istat.it (in Italian)

ISTAT 2017a. *CAPI Trips and Holiday Survey*. Available at: http://dati.istat.it/?lang=en# (in Italian)

ISTAT 2017b. *Capacity of Collective Accommodation Establishments and Occupancy in Collective Accommodation Establishments*. Available at: http://dati.istat.it/?lang=en# (in Italian)

ISTAT 2017c. *Capacity of Collective Accommodation*. Available at: http://dati.istat.it/?lang=en# (in Italian)

JFC 2016. *I piccoli Borghi Italiani – quando piccolo è bello* (The small Italian villages – when small is beautiful). Available at: www.jfc.it

Kaplant, R.A. and Nadlert, M.L. 2015. Airbnb: A case study in occupancy, regulation and taxation. *University of Chicago Law Review Online* 82. (1): 103–115. Available at: https://chicagounbound.uchicago.edu/uclrev_online/vol82/iss1/7/

Karlsson, L. and Dolnicar, S. 2016. Someone's been sleeping in my bed. *Annals of Tourism Research* 58. 156–170.

Macchiavelli, A. (ed.) 2011. *Le abitazioni di vacanza nella funzione turistica territoriale. Diffusione, problematiche ed esperienze di gestione* (Vacation homes in the territorial tourist function. Dissemination, problems and management experiences). Milano, FrancoAngeli.

Minuti, M.S. and Incipit Consulting 2016. *Il sommerso turistico nella provincia di Bergamo. Il fenomeno degli affitti brevi ai turisti* (The hidden tourism in the Province of Bergamo. The phenomenon of short rents for tourists). Paper presented at the meeting Il sommerso turistico nella provincia di Bergamo. Conoscere e contrastare l'abusivismo per promuovere l'accoglienza e il lavoro, July 19th 2016. Bergamo, Ascom Confcommercio Bergamo.

Oskam, J. and Boswijk, A. 2016. Airbnb: the future of networked hospitality businesses. *Journal of Tourism Futures* 2. (1): 22–42. Available at: https://www.emeraldinsight.com/doi/full/10.1108/JTF-11-2015-0048

Rátz, T., Kundi, V. and Michalkó, G. 2015. The hidden dimensions of cultural consumption within the framework of tourism mobility. In *Touring Consumption*. Eds.: Sonnenburg, S. and Wee, D., Wiesbaden, Springer VS. 285–302.

Richardson, L. 2015. Performing the sharing economy. *Geoforum* 67. 121–129.

Romita, T. 2010. Il turismo residenziale in Italia: un fenomeno sociale diffuso e fai da te. (The residential tourism in Italy: a widespread and do-it-yourself social phenomenon). In *Il turismo residenziale. Nuovi stili di vita e di residenzialità, governance del territorio e sviluppo sostenibile in Europa*. Ed.: Romita, T., Milano, FrancoAngeli, 35–66.

Zervas, G., Proserpio, D. and Byers, J.W. 2017. The rise of the sharing economy: estimating the impact of Airbnb on the hotel industry. *Journal of Marketing Research* 54. (October): 687–705.

Newspapers:

Gandolfi, A. (03/12/2017). Ornica, il borgo bergamasco salvato dalle donne delle montagne (Ornica, the bergamo village saved by the mountain

women). *Corriere della Sera*. Available at: www.corriere.it/buone-notizie/17_dicembre_03/ornica-borgo-bergamasco-salvato-donne-montagne-apple-0c2cca68-d832-11e7-83d0-5335217d8231.shtml?refresh_ce-cp#

Burgen, S. (02/06/2017). Barcelona cracks down on Airbnb rentals with illegal apartment squads. *The Guardian*. Available at: www.theguardian.com/technology/2017/jun/02/airbnb-faces-crackdown-on-illegal-apartment-rentals-in-barcelona

Kendal, M. (18/09/2016). Airbnb fights unfriendly regulations with wave of lawsuits against San Francisco, other cities. *The Mercury News*. Available at: www.mercurynews.com/2016/09/18/airbnb-fights-unfriendly-regulations-wave-lawsuits-san-francisco/

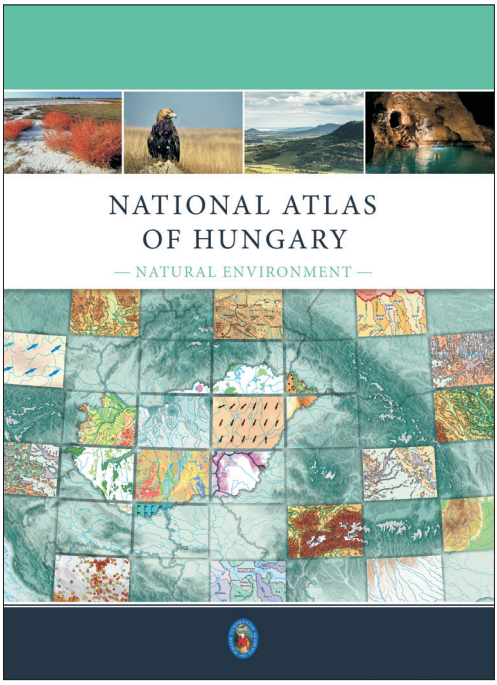
Oltermann, B. (08/06/2016). Berlin ban on Airbnb short-term rentals upheld by city court. *The Guardian.* Available at: www.theguardian.com/technology/2016/jun/08/berlin-ban-airbnb-short-term-rentals-upheld-city-court

BOOK REVIEW SECTION

Kocsis, K., Gercsák, G., Horváth, G., Keresztesi, Z. and Nemerkényi, Z. (eds.): National Atlas of Hungary Vol. 2: Natural Environment. Budapest, Hungarian Academy of Sciences, Research Centre for Astronomy and Earth Sciences, Geographical Institute. 2018. 183 p.

The current volume is Part 2 of the new "National Atlas of Hungary", and the first volume that has been published out of the four volumes, for Part 1 (*The Hungarian State and Its Place in the World*) will arrive later. Part 3 (*Society*) comes next, very likely in 2019, and Part 4 (*Economy*) is also to be published soon, before Part 1. A digital version will accompany the hardcopy of each volume, which will be distributed in two editions, Hungarian and English.

The list of editors and authors reads like a 'Who is who?' in Hungarian geography and cartography. At the top is Károly Kocsis, director of the Geographical Institute of the Hungarian Academy of Sciences, who is well-known for his previous atlases and other map works. Leading contributors also include László Zentai, head of the Department of Cartography and Geoinformatics at Eötvös Loránd University and secretary general of the International Cartographic Association (ICA), as the head of the cartographic advisory committee, and István Klinghammer, an outstanding representative of Hungarian cartography, as honorary president of the editorial board.



The current four volume project constitutes the third generation of national atlases in Hungary after the first such work in 1967, edited by Sándor Radó, and the second atlas in 1989, which was edited by Márton Pécsi and was later complemented by additional maps. Actually, one can also consider it the fourth generation if counting András Rónai's "Atlas of Central-Europe" from 1945 as a national atlas. Thus, Hungary might be the only country in Europe where so many national atlases were created since World War II. What is the explanation for that? Firstly, Hungary owes a very robust and devoted scientific community as well as outstanding researchers in geography, cartography and related fields. Secondly, the country has undergone several significant political changes in these decades, which required that cartographic representations of the country were frequently updated. Thirdly, there is a feeling of necessity to present Hungary to its own public as well as to the outside world, perhaps due to the country's fundamental political ruptures since World War I, the extreme temporal changes of the country's role among the nations of Europe, its reduction to the core of a larger nation and (even more so) territory, and, in consequence, its delicate geopolitical position in this part of Europe. As Károly Kocsis in his preface rightfully writes, national atlases are not only scientific outputs, but also national symbols. They present an image of the self that will affect and strengthen the consciousness of the country's population and shape the image of the country on the international scene, especially if the atlas, just like in the current case, also appears in a global language.

Who have already edited an atlas themselves know that editing atlases is the most demanding challenge in cartography. Contributors have to develop a comprehensive concept; find authors for the individual maps (137 units in the case of this volume); systemise and coordinate map and text manuscripts; provide for, if possible, distinct, innovative and also harmonious cartographic solutions appealing for potential readers; and, last but not least, they have to achieve the widest possible dissemination. In case of an English edition of an original work in a different language, as it is the case here, the editors also have to organise that native speaker scholars translate all ti-

tles, texts and legends, whereas the authors also have to check geographical and cartographic terminology.

The volume incorporates 13 chapters. Each chapter has its own colour code, and chapter numbers at the page margin as well as the numbering of maps and references to individual maps in the text also facilitate orientation. Contrary to the traditional concept, this atlas provides much more than a collection of maps. Maps catch the reader's eye, so they are dominant parts of the atlas, but detailed texts as explanations to the cartographic material constitute a much larger part of the volume than usual, and the plenty of very indicative photos also forms a crucial part of the project. A total of 33 maps represents the Pannonian or Carpathian Basin in the scale 1:800,000, going as far as Cracow [Kraków] in the North, Iaşi in the East, Zenica (Bosnia and Herzegovina) in the South and Linz in the West. Another 28 maps of Europe display Hungary in an even wider spatial context. Hungary as a cartographic island is represented in the scales of 1:1 million, 1:1.5 million, 1:2 million, 1:3.3 million, and sometimes even smaller. In addition, the atlas contains case study maps in larger scales. It is the editors' obvious intention not to show Hungary as an island, but to embed it into its wider neighbourhood, to which it was historically so closely connected, with which it has its intimate relations up to the present day, and with which it is, of course, also interwoven in terms of natural conditions. What would be the informative value of a drainage map or a map of natural landscapes confined to modern Hungary?

Cartographic design is excellent and very appealing as one can expect from Hungarian cartographers. Hill shading is decent, but applied not with many maps. In my experience, however, the fear of many cartographers that such shading makes more difficult to distinguish between areal colours is not a justified one. Hill shading in neutral grey never has a negative impact on visual distinction, while relief is important for the interpretation of almost all geographical topics, not the least those related to the nature sphere.

Place naming is always a challenging issue for national atlases targeting an international audience. An atlas with map titles, map legends and texts in more than one language can only work with endonyms, since multiple exonyms of all the languages applied would overburden the map face. With English as the only language of publication, like in the case of this atlas, a possible choice is to apply English exonyms. Taking this approach, the current atlas uses English exonyms for populated places, where they are available, in addition to the endonym. In minority areas with a minority's share of above 10 per cent the maps also provide additional endonyms from the minority language. Usually, only the English exonym is depicted to country names, names of natural features (e.g. relief and waters) and landscapes (with some exceptions), if such an exonym exists. In other cases, one or more endonyms are used. This is a reasonable approach for mapworks for an international English speaking audience.

Thematically, the current volume of the new atlas pays more attention to flora and fauna, nature conservation and landscapes compared to earlier national atlases of Hungary. Beyond this general feature, I can only highlight a couple of examples among the many topics the atlas embraces.

Chapter I (*Hungary at a glance*) offers a short introduction to Hungary's overall structure and situation in three pages, including a map of the country's administrative divisions (regions, counties and districts) as well as a geographical map of the 'Carpatho-Pannonian Area' with an impressive relief representation and detailed naming. It was, however, not a good idea to stretch the relatively small letters of a short name like 'Alföld' to such a length that the distance between individual letters is four centimetres. It is possible only by chance to identify this name amongst a jungle of traffic lines, rivers and other names. Would not it have been more consistent (and helpful in terms of visibility) to also use here the English exonym ('Great Hungarian Plain') – certainly along with 'Kisalföld' ('Little Hungarian Plain')? Would not it have even corresponded to the naming principles of the atlas only to apply the English exonym for landscapes? At this point it deserves to be mentioned that the editors obviously use the designations 'Carpatho-Pannonian Area' and 'Carpatho-Pannonian Region' to avoid the terms 'Pannonian Basin' and 'Carpathian Basin', which, according to editor-in-chief Károly Kocsis, have a well-defined meaning. Namely, the 'Pannonian Basin' marks the natural feature of the basin between the Alps, the Carpathians and the Dinarides, while the 'Carpathian Basin' describes ("without irredentistic connotations") "the historical-cultural homeland, the autochthonous settlement area of Hungarians, in fact, the historical territory of the state" (p. 12). Nevertheless, some maps depicting purely natural features also refer to "the Carpathian Basin" in their titles (p. 111, p. 113).

Chapter II (*Geology*, 20 pages) comprises stratigraphy, tectonics, petrography, energy and mineral resources, water aquifers and thermal waters. The map of engineering geology is rather exceptional for showing compressive strength of the ground as well as waste heaps and tailing ponds of mining sites and power plants.

Chapter III (*Geophysics*, 6 pages) highlights, among others, occurrences of earthquakes between the years 456 and 2014 in the Carpathian Basin. Concentrations are not so much in Hungary, but in Friuli, the upper Save area and the Dinaric Range in Slovenia and Croatia, the southern part of Romanian Moldova, and the southern area of the Vienna Basin.

Chapter IV (*Relief*, 16 pages) is very much based on the works of the late Márton Pécsi and starts with a 1:50,000 scale map of the geomorphology of Budapest,

where the network of main streets enables a very good comparison with current urban structures. It impressively shows the exposed, but at the same time safe, frontier location of Buda. Maps like "Terrain types of the Carpatho-Pannonian Area" demonstrate the benefits of the redundant numbering of categories which otherwise are marked with areal colours for safe map reading.

Chapter V (*Climate*, 12 pages) compliments the conventional thematic range with maps on expected future temperature change and seasonal precipitation change up to 2100. Long-term courses of temperature and precipitation are also very indicative of climate change.

Chapter VI (*Waters*, 12 pages) starts with a scheme of Hungary's water balance, which visually quantifies surface water entering and leaving the country, precipitation, evapotranspiration, direct surface runoff, infiltration into subsurface aquifers etc. Also very interesting is a series of small maps on the formation of watercourses in the Carpathian Basin, showing development since 4.5 million years ago, when Danube and Tisza flew into the Pannonian Lake, through the Pleistocene, when the Danube crossed the recent Danube–Tisza interfluve south of Budapest and the current location of the town of Szeged, up to a last stage before the contemporary pattern of watercourses emerged, when Danube as well as Tisza flew east of their current beds. Besides, the reproduction of a 1938 map is also very illustrative as it shows areas exposed to flooding in the Carpathian Basin before flood control and drainage works started. It is impressive to see that, especially in the Great Hungarian Plain, roughly half of the territory was subjected to occasional floods.

Chapter VII (*Soils*, 12 pages) contains a very instructive scheme of the typical soil top sequence of the Carpathian Basin with a curve of soil depths from higher to lower altitudes above sea level, with the profiles of typical soil types and pictures of the adequate scenery. There also are maps about land quality (soil bonitation values) as well as physical and chemical parameters of soils, with texts on their origin (natural vs. anthropogenic) and impact on agriculture.

Chapter VIII (*Vegetation*, 10 pages) starts with a map from Harald Niklfeld's "Atlas of the Danubian Countries", which depicts the natural potential vegetation, i.e. the vegetation that would presumably develop if humankind abandoned land use. Three maps on habitat diversity of vegetation regions interestingly demonstrate that the saline grasslands and nearly natural floodplains of the eastern lowlands show at a small overall diversity, but an intensive variation on the spot, whereas in the hilly and mountainous regions it is rather the other way round. Further innovative topics are the naturalness of forests and vegetation regions as well as the share of abandoned lands by vegetation region.

Chapter IX (*Animals*, 8 pages) presents several maps of Europe (and beyond) about the distribution of certain species also occurring in Hungary. In addition to these elementary-analytical maps, the chapter also provides synthetic maps of zoogeographical regions and faunal districts.

Chapter X (*Landscapes*, 18 pages) focuses inter alia on stability of land cover (or land cover changes) between 1990 and 2012 in Hungary. As it indicates, the most remarkable change in this period was the conversion of large areas of arable land to forests and close-to-natural areas. The 1:1.8 million map "Taxonomy of natural landscapes in the Carpatho-Pannonian area" at three levels is a most impressive one, and a successful attempt to harmonise various classifications of the wider area.

Chapter XI (*Environmental protection*, 14 pages) employs long time map series to reveal that the concentration of main air pollutants like sulphur dioxide or nitrogen dioxide has decreased since the Communist period, when Hungary belonged, especially due to its industrial belt in the North, to the countries with the highest air pollution in Europe. Still, there is a substantial amount of free of charge emission allowances as the map shows by industrial branches.

Chapter XII (*Nature conservation*, 12 pages) addresses various forms of nature protection. It also includes a double page about the most typical habitat types of the Pannonian Biogeographical Region as well as animal and flower species "of community interest", which the authors present through photos, maps on geographical spread, and explanatory texts. Presentations like these are very likely to remain in the mind of a wide range of readers.

The final Chapter XIII (*Natural hazards*, 12 pages) shows that the part of Hungary east of the Danube is the most endangered, and that floods and droughts are the most important reasons for that.

A list of authors by map, a bibliography, a list of sources by chapter, and a list of figures, tables and pictures, along with English exonyms and all corresponding endonyms, complete the volume. In some cases, the list of place names exceeds even this range of categories, when it, for example, mentions the German and Czech names for the Pre-Carpathians in Poland and Ukraine. It would, however, also be convenient to see the names of map authors in every map (not only at the end of the volume), perhaps in the right lower corner of the map field. One automatically would like to see the author(s) of synthetic maps like "Taxonomy of natural landscapes in the Carpatho-Pannonian area" (pp. 122–123), which very much are constructs depending on scientific perspectives, and it is annoying to find the author names only in a list at the end of the volume.

An overall evaluation of the first volume of the new national atlas of Hungary can only be very, very positive. Today, macroregional, national, regional, city and thematic atlases in both print and digital versions are very likely to receive the widest public attention

and recognition among all outputs of geography as a science – in cooperation with cartography –, for many consider regional geography texts outdated, and geography has diversified into very specific fields producing highly specialised outputs. Yet, with the significant share of texts and pictures this volume of the National Atlas of Hungary shows that it has integrated the functions of a written regional geography, and perhaps replaced it as well. Maps, also the dominant means of communication in this volume, have the benefit of urging systematic thinking while they provide a complete and homogenous coverage of the area. Therefore, one can expect the next volumes of this atlas series with great anticipation.

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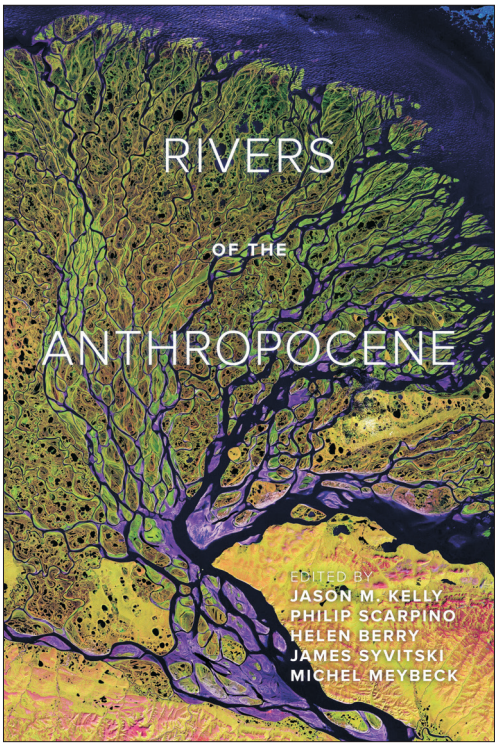
Kelly, J.M., Scarpino, P., Berry, H., Syvitski, J. and Meybeck, M. (eds.): Rivers of the Anthropocene. Oakland, University of California Press. 2017. 240 p.

Reading the title of the book, we think about streams in a new geological epoch, their geomorphological description or their role in our life. This book is much more than a simple introduction, it is a summary of the first results of the "Rivers of the Anthropocene (RoA) Network" project, established in 2013. The main idea that is followed throughout the entire book is human modification of the riverine environment (or river scape) to the extent that it became irreversible. Following a detailed historical overview of literature on human transformation of nature in general, citing well-known 19th and 20th century scientists, the authors emphasise the profound impacts of human activities on rivers during the past 250 years. Such impacts were induced by global population growth, the increased utilisation of fossil fuels, commercial activities extending over the whole world, and industrial processes, the production of chemicals, which have combined to lead to serious environmental consequences worldwide. Such consequences embrace, for instance, the decline of native species and, in parallel, the introduction of exotics as well as transformations in the chemistry and ecology of rivers caused by emissions from agriculture and industry practiced on the catchments.



Land drainage, river channelisation and impoundment, and wetlands development have also altered habitats and stressed ecosystems. In the background of all this is the human hubris, the thesis that humanity can control nature and have power over natural phenomena. In the authors' opinion, even if humanity could abandon this way of thinking, it would be already too late to get back to the old picture since a new, modified era that we call Anthropocene has already started. It is not just about environmental pollution, it is about changing the natural elements, like building dams and controlling rivers to the extent that the river's self-purification capacity is overstrained. People are not aware of the depletion of freshwater resources while 80 per cent of the world's population lacks healthy drinking water. The project's main objective is to make people realise the importance of rivers and their sustainable use in the future.

It was a very good idea to involve, in addition to natural scientists and engineers, also experts in other areas like social sciences in the writing of the book. Even artists, policy makers, and community organisers can have their contribution to the discussion across disciplinary and professional boundaries about the relationships between humans and their riverine environments. This is an important aspect because, as the authors explain in the book, there is not just one view of the Anthropocene, but there are many. Each layer of the population sees the epoch in a different way, and all the different opinions are considered relevant and important.

The original proposal for this book derived from Jason M. Kelly, Director of the Arts and Humanities Institute and Associate Professor of History at Indiana University–Purdue University Indianapolis and comprised two tasks to accomplish in the book: to recognise and diagnose the environmental pressures by using methods applied in natural sciences and engineering, and then to analyse the conditions that lead to them through approaches common in social sciences and humanities. It was hoped that transdisciplinary collaboration would allow the elimination of bad practices and bad decisions.

It seems that progress towards the Anthropocene is an irreversible and negative process that only brings bad outcomes. The authors refute this statement, for instance, through presenting the investigation of the Singapore River, a futuristic engineering project for island water with promising results for the future. In addition, authors deal with the Ethiopian Blue Nile basin, the English Fenlands, the Seine Basin and the Chicago River.

The chapter on the English Fenlands is of particular geomorphological interest. It presents an anthropogenic topography, the system of *roddon*s, sediment bodies

formed under the conditions of the Holocene, through differential compaction following draining. Now it is an Anthropocene landscape with inverted topography, as winding ridges rise 2 m higher than the surrounding clay surface. In the Fenlands they constitute the only higher ground, where local farmhouses are built.

The chapter on the Blue Nile in Ethiopia is particularly interesting for its societal aspects. Today no more than 5 per cent of water resources are utilised in Ethiopia. This explains that dam construction is on the rise. The proposed intensive use of the largest tributary to the Nile affects conflicting political and economic interests of Egypt and Sudan and calls for agreements on transboundary management. With regard to climate change infrastructure developments seem legitimate. However, irrigation projects do not necessarily decreased vulnerability to floods and droughts, especially if marginal groups of the population are considered. The large-scale projects underway may enhance existing inequalities. This is a typical example of the socio-economic implications of changes that the Anthropocene brings about.

The RoA project, which is aimed at improving the riverine environment, does not only comprise a theory, but also practical implementation. Each component has a software which depicts the river's conditions and geomorphological attributes. The first model is elaborated for the River Tyne in North England. A main issue to decide is when we should regard a river damaged, from which state the natural river scape cannot be restored. The methodology used here assesses the status of the river in the light of the provision of ecosystem services. The methodology is designed to be applicable worldwide for other medium-sized temperate rivers. In the background of the methods proposed two 'classical' approaches can be detected: conservation-based management and design with nature.

With respect to river restoration it is necessary to ask the question: What can we call a natural river scape? To give a precise answer is not easy, for at least two reasons. Firstly, there is no consensus about what are the reference conditions typical of a river in natural or semi-natural state. For instance, the vision of an 'ideal meandering form' was the widely accepted reference condition for restoration efforts in the river scapes of the United States. Before European settlement, however, anabranching systems transporting cohesive sediments in forested and swampy landscapes were the reality. Secondly, it is not agreed upon how to assess the fragmentation of catchments, which usually makes effective ecological restoration difficult. A key concept here is catchment connectivity, i.e. the unhindered communication between the main channel, the side-channels and oxbow lakes in the floodplain.

It is very hard to change back the river to its natural state, because for restoration the scientists should know river hydrology, hydraulics, geomorphology, ecology, and have to be sure that they will not cause more damage than benefit – as it has happened, for instance, with floodplains in Hungary. As a consequence of the river regulations of Tisza River, the country has lost most of its floodplains, marshes and swamps. To protect the remaining ones, we need to have much information on habitats, animals and plants living there. Back to the RoA's method, the help of the Google Earth or other virtual globe complements our knowledge which is necessary on the river (for example: fishing, timber, water supply, water quality control), we will have an output that represents these attributes with numerical data. Through Google Earth this information can reach people who badly need this knowledge: local residents and the policy makers.

Towards the end of the book a most interesting method is described and can be wholeheartedly recommended for use in Hungary. The essence of this method is to show people how they have to protect the riverine environment. The first model is the White River. It is common to have all the streets waterlogged in the settlements of Hungary after major rainfalls. People don't know that this is waste of freshwater vital for living. How can we show them this importance? The FLOW (Can you see the river?) is a project of the CALL framework in which they built a 6-mile-long path from the Indianapolis Museum of Art to White River State Park. There are a few stations on this path, where people can learn about the infrastructure of the river, its history and ecology, and if they want to know more, there is a chance to access the webpage. At the stations there are big mirrors made from stainless steel, signed with a lot of red dots on its surface with their descriptions. Looking at the mirrors from different angles, the dots show the visitors different pieces of information on the river, this way they can see themselves in the mirror in relation to the river. The Indianapolis Museum of Art also has a walkable map with the size of 40 m^2, where visitors can find their home, workplace, locations, so they can learn about their relation to the river. The project already got a lot of positive feedback from people who said they had not known much about the river's importance until they learnt about this project.

Summarising the RoA project's first result, this is a very profound work to make people realise how important the rivers around us are. Although the authors naturally cannot achieve fundamental changes in the world with their book, but this is an excellent initiative to spread useful thoughts and methods across the world, to reach the people of Anthropocene.

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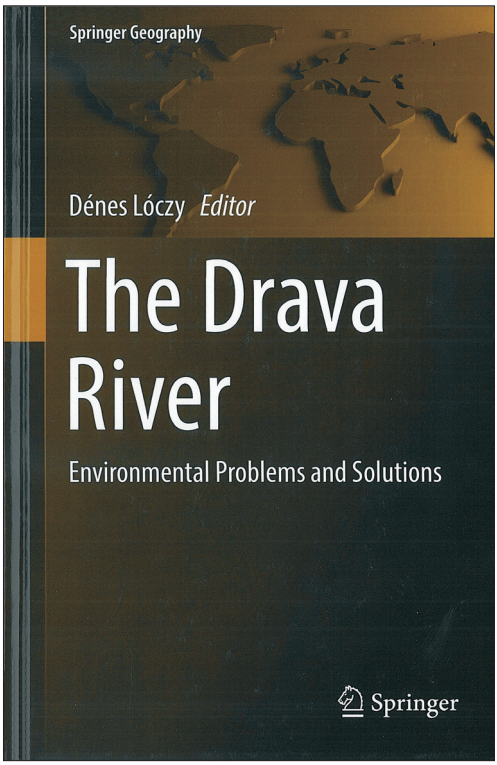
Lóczy, D. (ed.): The Drava River: Environmental Problems and Solutions. Cham, Springer, 2019. 399 p.

It is uncommon in Central Europe that an all-encompassing geographical monography addresses the entire catchment area of a 749 km long river. One obvious reason for this is the political fragmentation of the area the river runs through, and that, as a result, it required 100 years of international cooperation to prepare a book of this kind. We might also say that it took 100 years for the inclination to such a cooperation to be born.

The foreword of Mauro Soldati, the president of the International Association of Geomorphologists (IAG), is followed by a short introduction of the editor, Dénes Lóczy (University of Pécs). The editor emphasises the peripheral and, in terms of military strategy, sensitive location of the river, which explains the negligence of its scientific investigation before the border zones opened with the political transformations in 1989–1990, and the end of the Serbo-Croatian War in 1995. The introduction highlights the use of the river's power by hydroelectric power stations, but it also underlines the resulting environmental problems, and pointing at the importance of taking into consideration the environmental problems of the river channel and the floodplain area after channel construction and the regulation and harnessing of the river. In spite of the hydropower constructions the river channel and the cut-off meanders provide valuable habitats for wildlife, which the UNESCO Transboundary Biosphere Reserve as well as numerous Ramsar and Natura 2000 sites along the river prove. The introduction of the book discusses different aspects of the maintenance of this natural heritage, the improvement of its quality, and the rehabilitation potential of the river channel and the floodplain. The chapter also emphasises the need for international cooperation in solving environmental challenges in the area.



The second chapter by Dénes Lóczy describes the geological and geomorphological setting of the Drava Basin, dividing it into three major units: the Austro-Alpine Nappe System, the South-Alpine Nappe System and the southwestern margin of the Pannonian Basin. It concludes that the river catchment area is extremely varied and picturesque in terms of geological structure and surface forms. The chapter focuses on the geological and geomorphological description of the catchment area instead of geological units, which is a novel approach and perfectly fits the objective of the book.

The authors of Chapter 3, Gerhard Karl Lieb and Wolfgang Sulzer, describe in detail the current land use and recent changes of the Drava basin based on the CORINE Land Cover database. They conclude that the land use pattern and the dominant classes of the western and eastern parts of the basin significantly differ not only for natural, but also for cultural reasons. Based on land cover data, the authors evaluate the environmental status of the area as satisfactory, not least because of the relatively big protected areas within the basin.

Chapter 4 by Dénes Lóczy discusses climatic conditions and climate change in the Drava Basin. There are remarkable differences within the catchment area, carrying characteristics of Atlantic, Mediterranean and continental climates as well as orographic influence. Due to climate change, the difference between these four types are expected to increase further. The spatial and temporal pattern of the river regime is definitely determined by snowmelt in upper sections of the river, and only moderately affected by continental climate along the downstream.

Ulrich Schwarz's chapter (Chapter 5) focuses on the hydro-morphology of the Lower Drava. At the downstream of the Mura confluence the river shows

anabranching characteristics, which transform to meandering type for the gradual decrease in the slope. The chapter describes the sediment types, the geomorphological character, and their evaluation from the perspective of the numerous upstream hydropower plants. It concludes that the long-term effects of hydropower dams on the interrupted sediment continuum and channel type call for the need for reconsidering river management and floodplain restoration.

Lidija Tadić and Tamara Brleković summarise in Chapter 6 the hydrological characteristics of the Croatian section of the river. They point out that regulation and dam construction enable the control of high water levels, but the backwater effect of the Danube still affects the lowest section of the river. The authors find that drought periods and low discharge are becoming more and more frequent in the last decades.

Enikő Anna Tamás characterises in Chapter 7 the sediment transport of the river. She analyses in detail the bedload and bed material, the suspended load concentration, and their variability with the discharge. The study concludes that the typical processes of river morphology are reservoir armouring on the upstream, but rather riverbed erosion on the downstream.

Chapter 8 by Hrvoje Petrić, Enikő Anna Tamás and Dénes Lóczy describes the history of regulation and documented floods along the river. The authors summarise the major flood events in four countries with their estimated discharge, as well as early and modern time regulation history, the state of navigation, and the data of hydropower plants. Concerning future the authors point at the changes of river management, as it is turning from hard engineering to ecologically based restoration activities.

In Chapter 9 Ognjen Bonacci and Dijana Oskoruš connect to the previous chapter, and deal with human impacts on the water regime of the river, changing hydro-morphological characteristics, and sediment transportation of the river. The chapter shows that human activity substantially influences the water regime of the Drava River, even in downstream sections, and underlines that more efficient and interdisciplinary international cooperation is essential to preserve the still remaining, but very vulnerable, fluvial landscape and environment.

In Chapter 10 three authors (Alajos Burján, Gábor Horváth and László Márki) write about the river channel incision along the Hungarian section of the Drava. The study shows that the river channel not yet reached the hydro-morphological equilibrium due to relevant human interventions. Regulation increased the channel gradient, and the construction of hydroelectric plants reduced the sediment supply. Altogether these processes generated significant channel incision on the downstream sections.

Tímea Kiss and Gábor Andrási analyse the evolution of the Drava floodplain during the last 100 years along the downstream section of the river. They find that the floodplain area has increased by several thousands of hectares, while the channel area has been decreasing simultaneously. Old abandoned channels lose their water conductivity due to incision of the channel and islands which have been merged to the floodplain. Meander development has accelerated and the stability of eroding banks has decreased. Lateral erosion can contribute to local sediment yield.

The following two chapters (Chapter 12 by Dénes Lóczy, József Dezső, Péter Gyenizse, Szabolcs Czigány and Gabriella Tóth and Chapter 13 by Adrienne Ortmann-Ajkai) present the cut-off oxbow lakes along Drava River. The first study evaluates and classifies the oxbows based on their geographical position, their connection with the main channel, their water retention capacity and relation to the groundwater flow. This kind of analysis may prove very helpful while planning the rehabilitation or restoration of the floodplain. The second study addresses the vegetation and its development around the oxbows, which are regarded as valuable biodiversity refuges in an environment dominated by agricultural fields. The study asserts that the aquatic and riparian vegetation of the oxbows are relatively well-preserved due to the moderate intensity of land use, its location along national boundaries, and efficient nature conservation policy. It considers the terrestrialisation of habitats due to river incision an unavoidable treat.

József Dezső, Dénes Lóczy, Ali Mohamed Salem and Gábor Nagy deal with floodplain connectivity in the next study. They consider the connectivity of cut-off oxbows to the main channel as the most relevant factor of maintaining biodiversity and other vital ecosystem services. Due to river regulation, disconnected or geographically isolated oxbows have become the most common in the Drava floodplain area. Hence, the authors consider the potential of subsurface water supply. For this reason, they calculate the effective porosity and hydraulic conductivity of floodplain deposits, and apply hydrological modelling to estimate groundwater streams. The authors regard subsurface water supply as a key factor in floodplain rehabilitation planning as well.

Chapter 15 by Anita Dolgos-Kovács, Gabriella Tóth and Dénes Lóczy analyses the water quality of the lower section of the river. Although the upper and middle sections of the river were assessed to have good water quality, the authors consider that many features of the river catchment area, like land use intensity and erosion, influence water quality at the downstream section. They evaluate water quality according to hydro-morphological, physio-chemical, biological and biochemical parameters. The study also discusses assessment according to the European Water Framework Directive. Not only the water qual-

ity of the river itself, but also the tributaries within the Hungarian part of the catchment area are depicted in colour maps. Compared to the major rivers in Hungary, the Drava proves to be one of the cleanest rivers and water bodies of the country. The chapter also employs a case study evaluating the water quality of an oxbow lake.

Chapters 16 and 17 provide an inventory of selected taxa of the river, and insofar macroinvertebrates and fishes are good indicators of water quality, they concentrate to them. From the macroinvertebrate fauna the *Mollusca, Annelida, Crustacea Chelicerata* and *Insecta* are listed in the river channel and from the floodplain in the chapter by Arnold Móra and Zoltán Csabai. The authors conclude that the macroinvertebrate fauna of the river is one of the richest ones among Hungarian floodplains. Numerous Natura 2000, protected, and strictly protected species indicate the conservational significance of the region, whereas the large number of non-indigenous species signs the vulnerability of aquatic communities. Similarly, Péter Sály's study on the fish fauna of the river reveals the semi-natural status of fish assemblages. The ratio of native and non-native fish species reflects an overall good ecological status of the riverscape. Therefore, the actual good quality of the river along the Croatian-Hungarian section has to be maintained.

The relatively long Chapter 18 by Balázs Kevey provides an excellent systematic overview of floodplain forest communities in the Drava Plain. Beyond describing willow shrubs, softwood and hardwood forests, and bog forest communities, it also discusses their interconnections. Numerous figures with cross sections show typical toposequences and the coupling of forest communities to micro-topography, pedodiversity pattern and microclimate. The analysis of theses typical landscape patterns is a useful basis for ecological forest management and reforestation of deforested potential hardwood habitats.

Chapter 19 by Dénes Lóczy and Rok Ciglič evaluates nature conservation in the Drava catchment area. The study deals not only with the variety and the extent of protected areas like national parks and nature parks, but also stresses that the restoration of riverine habitats, floodplains and river channels has become an integral part of nature conservation strategies. Rehabilitation of riverine landscapes not only increases the habitat diversity through establishing gravel and sand bars, but also facilitates the management of riverine landscapes, directing them into more and more self-sustaining conditions.

The last two chapters of the book (Chapter 20 by Tibor Parrag and Dénes Lóczy and Chapter 21 by Dénes Lóczy and József Dezső) present accomplished side-channel and floodplain rehabilitation projects, and also the largest-scale actual landscape rehabilitation project in Hungary. The authors critically present the rehabilitation potential based on ecosystem services and landscape functions.

Two-thirds of the 29 authors who wrote the 21 essays of the book are from Hungary. Five contributors are from Croatia, three from Austria, one from Slovenia, whereas the Italian source of the river is symbolically represented by the inaugural lines of an Italian colleague. These contributions of course do not follow a strict thematic division, as the phenomena, attributes and qualities of the upper and lower reaches of a river are always close intertwined. It is not by chance that the subtitle of the volume is "Environmental Problems and Solutions", since there are significant hydrological, geomorphological and biogeographical consequences of the heavy anthropogenic impact along the upstream section of the river. This generates new, often political controversies, which cross-border nature conservation projects can only partly counterbalance. An important aim of the editor was with the detailed analysis of environmental issues to identify positive outputs and possible solutions to the problems. The volume presents several great examples of river restoration projects in Austria, Slovenia and Croatia. Another important element of this positive vision is the Hungarian 'Old Drava' landscape rehabilitation programme, which is implemented at the landscape level, and, at the same time, represents the most up-to-date approach to managing environmental problems as it is focusing on ecosystem services. Accordingly, the book intensively discusses topics like flood storage, local climate regulation, water-sport possibilities, and revitalisation of traditional forms of agriculture, including the reintroduction and local processing of old fruit species.

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CHRONICLE

In memoriam György Várallyay (1935–2018)

On 2nd of December 2018 Hungarian soil science lost one of its most prominent and best-known representatives, György Várallyay, agricultural engineer, soil scientist, university professor, ordinary member of the Hungarian Academy of Sciences, holder of the Széchenyi Prize. Remembering his contributions to earth and environmental sciences, his passing can be regarded a major loss to those disciplines, too.

Following the example of his father, the agrochemist György Várallyay Sr. (1900–1954), György Várallyay Jr. began his studies at the Agricultural University of Gödöllő (now: Szent István University) in 1952. With a degree as agricultural engineer, he found a job at the Department of Soil Science of the National Institute for Quality Analysis in Agriculture (OMMI) in 1957. In 1960 he became research fellow at the Department of Utilization of Alkali Soils of the Research Institute for Soils Science and Agrochemistry (RISSAC), Hungarian Academy of Sciences. This is the Institute to which he remained faithful throughout his career. With his scientific results on the processes of the evolution of salt-affected soils, he contributed to the assessment of the environmental impacts of the Tisza II Irrigation System and to the prevention of alkalisation of soils in the extensive areas where the irrigation scheme modified water availability and groundwater tables.

He defended his university doctor's dissertation at the University of Agriculture in Gödöllő in 1964 and received the Candidate of Agricultural Sciences degree in 1968 for his investigations of salt accumulation continued for the soils of the Danube Valley. Returning from a scholarship in the Netherlands, his interests turned towards soil physics and soil water management. In team work he elaborated up-to-date standards for soil physical and water management analyses, which were published as directives by the Ministry of Food and Agriculture in 1978. He encouraged and supported the AGROTOPO project, coordinated by the RISSAC, which was aimed at the compilation of a detailed soil database and mapping for Hungary at 1:100,000 scale.

In 1976 he was appointed head of the Department of Soil Sciences and in 1981 director of the whole Institute, which position he held for 26 years. His investigations focused on soil hydrology and his academic career continued with the following degrees: The Doctor of Agricultural Sciences in 1988, corresponding (1993) and ordinary member (1998) of the Hungarian Academy of Sciences, where he was the leader of various professional commissions. At the international level, he was member of the International Union of Soil Science and president of its Commission VI between 1982 and 1986, as well as president of the Hungarian Soil Science Society between 1990 and 1999. As university professor he was active in Gödöllő, Debrecen and Budapest. He also was titular professor at the University of West Hungary and the University of Debrecen. Listening to his enjoyable lectures, many students came to like soil science and soil hydrology – generally considered boring subjects by non-professionals.

He spoke Russian at medium and English at high level and his language skills helped him build international contacts. Utilising his experience in the study of alkali soils in Hungary, he worked in Yemen and in 1977 lectured in Egypt, at the Ain Shams University of Cairo, a huge institution of higher education, which has 170,000 students at 14 faculties now. In 2005 he retired as head of the Department of Soil Science, a unit of higher education which operated within the institutional frame of the RISSAC.

As part of his international recognition, Professor Várallyay became member of the Slovakian Academy of Agricultural Sciences. He assisted in launching the academic career of numerous young scientists as editor-in-chief of the renowned professional journal *Agrokémia és Talajtan [Agrochemistry and Soil Science].* In addition, for long years he was on the editorial boards of other journals in Hungary and abroad *(Hidrológiai Közlöny, Acta Agronomica, Geoderma, International Agrophysics, Land Degradation and Rehabilitation, Soil Technology),* too.

Over his almost six decades of acedemic career, György Várallyay published more than 550 scientific papers and – partly with co-authors – 23 books, cited more than 2,200 times worldwide. He actively influenced Hungarian environmental policy as member of the National Board for Environmental Protection. In 1997 he was decorated with the Medium Cross, Order of Merit of the Hungarian Republic, and in 2004 with the Széchenyi Prize.

Some of his thoughts on soil fertility, degradation and water management will always resound in the ears of all who read his works and listened to his lectures, which were based on a collection of hundreds of transparencies. Each of them presented some of the intricate interactions among soil characteristics in very clear form. For instance, the properties which

control soil resilience were shown in flow charts. He called the soil a reactor and transformer which integrates the combined influences of other natural resources and fulfills the ecological requirements of living organisms. For this reason, he always showed deep interest in the achievements of disciplines closely related to soil science, including physical geography and environmental sciences.

He regularly visited the biannual conferences of landscape ecology and held interesting lectures there. Focusing on his favourite field of research, soil water budget, he emphasised the significance of soils for humankind – as we say today, in the provision of ecosystem services. He held that water storage is of special significance in the Carpathian Basin, an increasingly water dependent region under the conditions of global climate change. In recent decades he studied the impacts of extreme weather conditions on soils. He researched to what extent – through their high buffering capacity – soils can moderate environmental stresses.

He was deeply worried about soil degradation processes (desiccation, alkalisation, acidification, erosion, compaction etc.) of both natural and anthropogenic origin. Among the mapping projects he took part in the preparation of the world map of soil degradation stands out. On every forum he called for soil conservation and warned against the over-exploitation of the soil, a fundamental natural resource, a gene pool, part of the world heritage of humanity.

His co-workers and students and, in fact, everybody who knew him personally will keep his infinite wisdom and cheerful, grandfather-like personality in good remembrance.

Dénes LÓCZY

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2016–2018

The editors of the Hungarian Geographical Bulletin would like to thank the following people who have offered their assistance in reviewing manuscript submissions to our journal issues between Number 1 in 2016 and Number 4 in 2018. Their efforts and useful comments have been of great service for the authors and the journal.

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Books:
Pye, K. 1987. *Aeolian Dust and Dust Deposits.* London, Academic Press.

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