

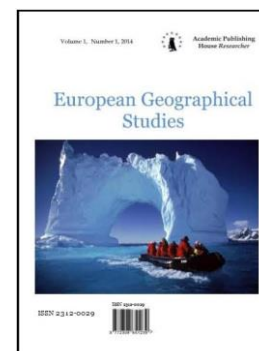
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## Identificaton and Assessment of Geoheritage Objects in the Karst Landscape (Niksic Polje, Montenegro)

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### Abstract

The presented paper aims at proposing and evaluating potential geoheritage objects in Niksic polje, a karst field located in western part of Montenegro. According to scientific literature, cartographic sources and requirements which are set out in the Nature Protection Law, four objects of geoheritage were suggested: estavelle Gornjepoljski vir, karst spring Vidov brook, hill Trebjesa and slope Slivlje. Once identified, objects were evaluated in order to show their significance. Assessment method integrated scientific, aesthetcal, ecological and morphometric values, combined with analysis of dangerous natural processes which can influence physical state of landscape. Based on the evaluation and inventory of potential objects, the first geodiversity map for research area was accomplished. The interpretation of results allows us to compare sites and use them to support tourist and management decisions.

**Keywords:** Montenegro, Niksic polje, geoheritage, asessment, karst.

### 1. Introduction

Value of a certain area reflects in its richness and diversity of the natural elements. Karst landscapes are recognized by their unique underground and surface forms of the relief, specific forms of biocenosis and complex structure of hydrological network (Zhyrnov, 2015). All those natural elements represent geodiversity, from which representative objects of geoheritage are selected (Pantić et al., 1998). According to Nature Protection Law (Official Gazette of Montenegro, 62/13) geoheritage represents all geological, geomorphological, soil and the special archaeological values created during the formation of the lithosphere, its morphological shaping and interdependence of nature and human culture. Most of these objects are located in nature, with the exception of different mineralogical and paleontological collections that are in the museum premises (Moscicka, 2011). Geological structure of Montenegro caused a remarkable geomorphological diversity. The large limestone terrain led to different karst processes that have contributed to the creation of numerous phenomena and forms of surface and underground relief (Djurovic et al., 2006).

The data collected by significant institutions shows that some parts of Niksic polje are for many years among one the most vulnerable areas in Montenegro. A special impact on this situation

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has inadequate application of the adopted laws and underdeveloped environmental awareness of citizens. Some of the geoh heritage objects are partially protected through various levels and forms of legislation. However, it is necessary to make a new (official) list of objects that will be nominated for the protection as geological heritage, representative objects of geological diversity.

The presented paper aims at suggesting and evaluating geoh heritage objects in Niksic polje, Montenegro. Methodology includes identification of potential objects, their quantification and analysis of results. The interpretation of results allows a comparison between sites and is of particular use in supporting site management decisions (Pereira, Pereira, 2010).

## 1. Materials and Methodology

### 2.1 Research area

Niksic polje is the largest karst field in Montenegro, with area of 66.5 km<sup>2</sup>. Its complex hydrological conditions and the development of various forms of relief makes it one the most interesting karst fields (Radojičić, 2015). Because of its uniqueness, since 2000, an initiative was launched for the protection and monitoring of natural resources by the Institute for Nature Protection. As a result, two natural objects, Trebjesa hill and estavelle Gornjepoljski vir, were protected.

Because of the absence of official list of geoh heritage objects in Montenegro, in this paper, preliminary list of potential objects classified according to international standards of The European Association for the Conservation of the Geological Heritage (ProGeo) is proposed. The first stage was to investigate the geological and geomorphological conditions based on available scientific articles and cartographic sources in order to identify potential objects. Once identified, objects were outlined on the geological map. In addition to the general requirements which are set out in the Nature Protection Law (Official Gazette of Montenegro, 62/13), of great importance was that objects met the appropriate criteria such as representativeness, rarity, the aesthetical value, the possibility of cost-effective conservation, possibility to use for educational and tourist purposes, etc. (Reynard, 2005; Pereira et al., 2007; Pralong, 2005).

According to ProGeo, geoh heritage sites are classified into nine main groups: historical-geological and stratigraphically sites heritage, structural sites, petrological sites, geomorphological sites, neo-tectonic activities sites, speleological sites, hydrological-hydrogeological sites, pedological sites and archeological geoh heritage sites (Wimbledon, 1996; 1999). Of nine given groups, two are presented in the research area: geomorphological and hydrogeological. Suggested objects in these groups are: Trebjesa hill (geomorphological group), estavelle Gornjepoljski vir, intermittent spring Vidov brook and slope Slivlje (hydrogeological).

### 2.2 The assessment methodology

The possibility of measuring and evaluating geoh heritage is unambiguously related to the effectiveness of the incorporation of geodiversity in land management (Serrano, Purificacion, 2007). Due to that, various assessing methods have been developed. With aim to reduce subjectivity, most of these methods propose criteria (Reynard, 2007) such as scientific, aesthetical and ecological value (Zhyrnov, 2015). Because of the nature of karst terrain in Montenegro, author pays significant attention to analysis of potential threats which can influence physical appearance of area and/or tourist traffic (Zhyrnov, 2015). According to Zhyrnov (2015) morphometric characteristics represent an important aspect of assessment because they define visibility, attraction, variety and passability of the terrain. Applied methodology merges mentioned estimation values with morphometric characteristics and possible dangerous natural processes (Zhyrnov, 2015).

#### 2.2.1 Scientific value

It is generally accepted that scientific value represents the essential value of geoh heritage object (Pereira, Pereira, 2010). In the domain of scientific value, criteria like integrity, representativeness, rareness and diversity are stressed (Table 1) (Zhyrnov, 2015). The last and the one important is paleogeographical value that allows us to evaluate the importance of the site for the knowledge of Earth and climate hisroty (Reynard et al., 2007).

### 2.2.2 Aesthetical value

Aesthetical value has a significance in tourist valorization. According to literature on landscape perception, contrasted landscapes, landscapes with pronounced vertical indentation and color contrasts are considered to be more attractive (Reynard et al., 2007). Its assessment can be very subjective and it consists from such categories as: uniqueness of landforms, architectonic composition, visibility, exoticism, attendant effects, compatibility with other elements of landscape, pictorialism, photogeny, emotinal perception and ethnic and social significance (Zhyrnov, 2015, modified).

**Table 1.** Numerical assessment of scientific value

Scientific value	Short characteristic	Points
Integrity (State of conservation)	Highly damaged	0
	Damage but preserving essential geomorphological features	1
	Slightly damaged but still maintaining the essential geomorphological features	2
	No visible damage	3
Representativeness (Exemplarity)	Low representativeness and whitout pedagogical interest	0
	With some representativeness but with low pedagogical interest	1
	Good example of processes but hard to explane to non experts	2
	Good example of processes and good pedagogical resource	3
Rareness (Rarity of the object with respect to a reference space)	More than 5 occurrences	0
	Between 3 and 5 occurrences	1
	2 occurrences	2
	The only occurrence	3
Diversity (Number of different partial features and processes whitin the karst object)	1	0
	2	1
	3	2
	More than 3	3
Paleogeographical value	Absence	0
	Low value	1
	Weighty value	2
	Important value	3

Source: Zhyrnov,2015

### 2.2.3 Ecological value

Ecological value represents the level of protection according to environmental legislation (Pereira et al., 2007) and any anthropogenic variations presented at the site. The parameters of the ecological value are:

1. Level of anthropogenic variation of the relief (changes in the original appearance, the presence of metal or wooden structures, tourism infrastructure, etc.).
2. Presence of anthropogenic garbage such as food waste, grocery containers, used equipment, etc.
3. Changes of the air, existence of unpleasant smells or evaporations (Zhyrnov, 2015, modified)

Aesthetical and ecological values are measured with a tree-point scale. Each criteria is evaluated with points from 0 to 3, where 3 presents significant intensity (aesthetical value)/absence of change (ecological value) (Zhyrnov, 2015, modified).

#### 2.2.4 Safety of object

One of the key criteria in the evaluation of any object of geological heritage is the safety of visitors. The karst landscapes are characterized by a variety of natural processes that can lead to accidents. Such natural processes include earthquakes, landslides, occurrence of landslides or avalanches. They can lead to changes in ecosystems, physical state of landscape as well as the stability of tourist infrastructure. Therefore, it is very important to take account of the potential risks in the field when evaluating geoheritage objects (Table 2).

In addition to these values, the classification of geological heritage facilities in karst terrain requires good knowledge of morphometric characteristics, such as elevation, slope, aspect and diverse of the relief (Table 3). These features greatly affect the possibility of valorization. Height affects the view that stretches from a certain area, which is connected with the mental and emotional effects of visitors. The slope of the terrain and exposure determinate the ability of building recreational and tourist facilities. Diverse relief affects the possibility of building transport infrastructure, the wealth of the various forms of relief and overall aesthetic experience.

**Table 2.** Estimation scale of possible dangerous natural processes

Index of natural processes danger	Kinds of dangerous processes	Points
Catastrophical processes	Earthquakes	0
	Landslides	
	Avalanches	
	Mudflows	
	Screes	
Dangerous processes	Failures of the carbonate breeds roof	1
	Dissolution of carbonate rocks	
	Aggressive action of karst groundwater	
Negative processes	Overcooling	2
	Overheating	
Absence		3

Source: Zhyrnov, 2015

**Table 3.** Estimation scale according to morphometric criteria

Absolute altitude (m)	Gradient of slopes (°)	Depth of relief ruggedness (m)	Points
0-500	0-6	<300	0
500-1000	6-12	300-600	1
1000-1500	12-45	600-800	2
>1500	>45	<800	3

Source: Zhyrnov, 2015, modified

## 2. Results and discussion

Each of suggested objects was assessed with the methodology presented above (Table 4) and represented on a map.

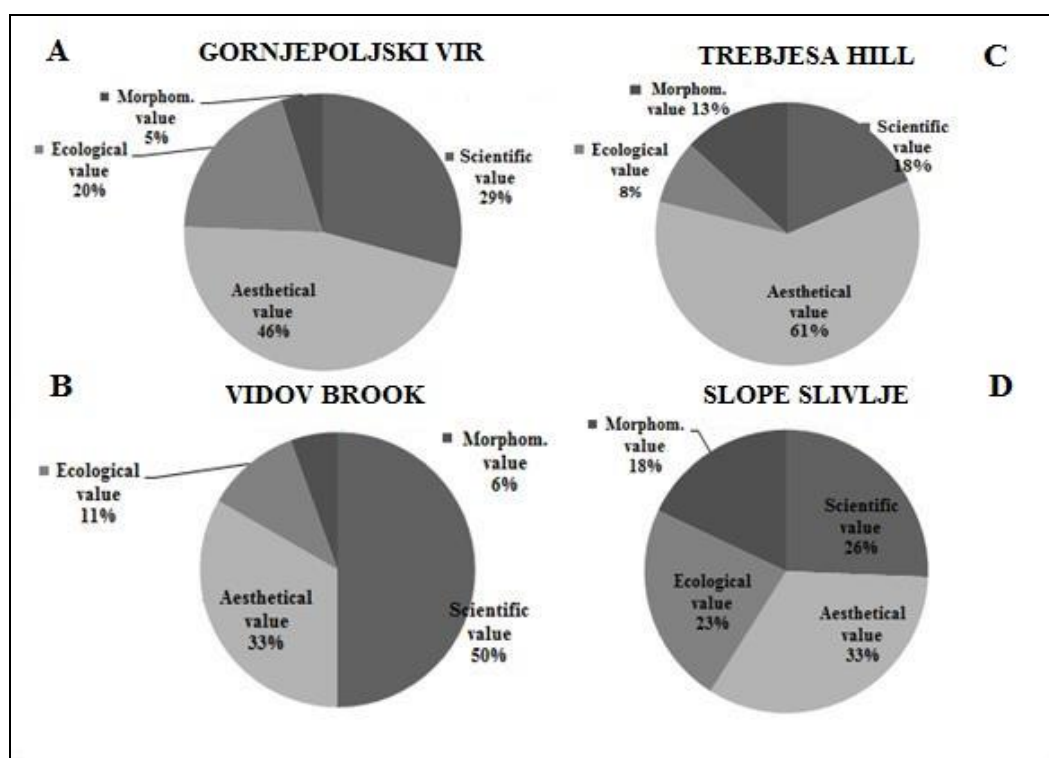
The scientific value is most pronounced in the estavelle Gornjepoljski vir, one of the biggest estavelle in the Dinarides, because of its preservation and paleogeographical value. In addition to this, the site is currently used for educational and tourist purposes. Aesthetical value is most evident at Trebjesa hill which is directly connected to its expressed morphometric characteristics. They affect visibility, exoticism and photogeny of object, and thus the grater emotional perception of visitors. The greatest ecological value has the slope Slivlje, as the only object that is currently not available to tourists nor modified by any anthropogenic activities.

**Table 4.** Assessment of geoheritage objects in Niksic polje

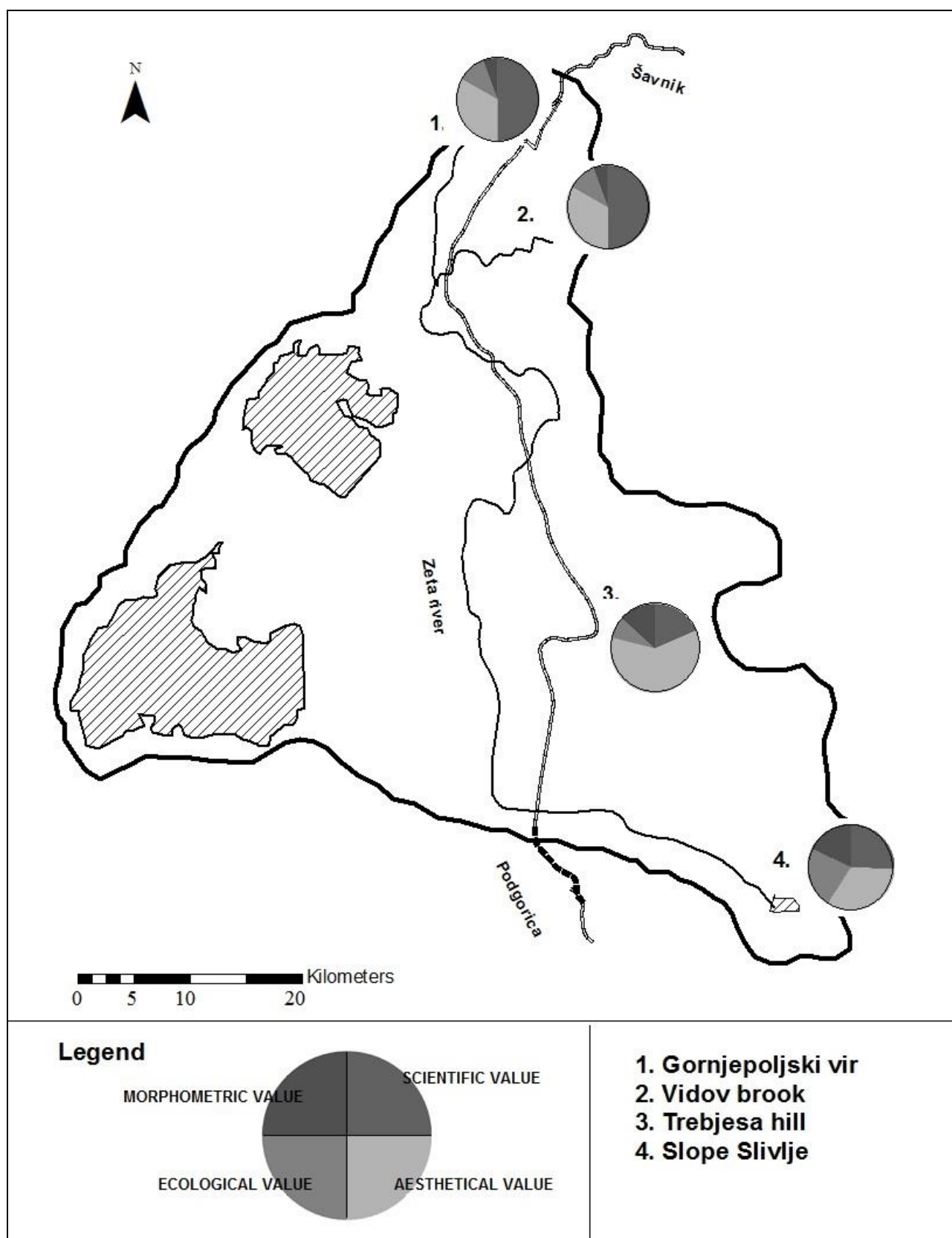
Criteria		Gornjepoljski vir	Trebjesa hill	Vidov brook	Slope Slivlje
Scientific value	Integrity	2	2	1	3
	Represent.	3	2	2	2
	Rarity	2	2	2	2
	Diversity	2	0	1	0
	Paleogeogr. value	3	1	3	3
Total		12	7	9	10
Aesthetical value	Uniqueness	3	2	3	2
	Composition	3	2	0	0
	Visibility	3	3	1	0
	Exoticism	1	3	0	3
	Attendant effects	1	3	1	2
	Compatibility	3	2	0	0
	Pictorializm	2	3	1	3
	Emotional perception	3	3	0	3
	Ethnic and social sign.	0	2	0	0
Total		19	23	6	13
Ecological value	Level of antropogenic variation of the relief	3	2	0	3
	Presence of antropogenic garbage	3	1	0	3
	Changes of the air	2	0	2	3
Total		8	3	2	9
Dangerous natural processes		0	0	0	0
Morpho m. Value	Absolute altitude	1	1	1	1
	Gradient of slopes	1	2	0	3

	Depth of ruggedness	0	2	0	3
	Total	2	5	1	7
<b>All criteria</b>	$\Sigma$	<b>41</b>	<b>38</b>	<b>19</b>	<b>39</b>

Based on the analysis of the total value of estavelle Gornjepoljski vir (Fig. 1a), it can be concluded that scientific and aesthetical values are prevailing. Aesthetic value is reflected in the landscape contrast of the water surface with karbonant layers in the hinterland, which is, due to existing protection, minimally modified by anthropogenic activities. The fact that this is the biggest estavelle in Montenegro gives it greater scientific importance. In accordance with these values facility has a predisposition to be used for educational and tourism purposes.



**Fig. 1.** Results of assessment for all four investigated localities



**Fig. 2.** Geoheritage map of Nikšić polje

Examining the proposed object Vidov brook (Fig. 1b), it can be concluded that minor aesthetic and ecological value stems from the fact that the object was modified by anthropogenic activities and has not preserved its original appearance. Nevertheless, intermittent spring has

greater scientific importance because it is a rare occurrence in karst terrain. Due to the non-existent protection it is necessary to first declare the object a monument of nature, and then valorize it for educational purposes.

Pronounced morphometric characteristics of Trebjesa hill (Fig. 1c) appear as a result of higher slopes and greater segmentation of relief. Thus they contributed to the higher aesthetic value of the site. The scientific value stems from the preservation of the object and the variety of processes that have contributed to its formation. It adds to the specific flora and fauna of the area. All this resulted in a major tourist and educational importance, which is already recognized.

Notable ecological value of the slope stems from its less accessibility for regular visitors. This has precisely effected on the smaller scientific and aesthetic value. Although not suitable for tourism development, we should not neglect its educational and scientific importance in the study of hydrology and hydrogeology in karst terrain. The object has not been fully studied, which leaves place for further research for domestic and foreign experts (Fig. 1d).

Based on the inventory and assessment of suggested geoheritage objects, by using GIS techniques, the first geoheritage map of this area was made (Fig. 2). On it, the scientific, aesthetical, ecological and morphometric values are represented. The distinction of each circle into four parts represents the contribution of each value.

Proposed map can have its contribution in territorial planning, managing geotouristic products, process of geoconservatio, etc. (Comanescu et al., 2013).

#### 4. Conclusion

During the last decade, the promotion of geoheritage raised rapidly due to creation of geoparks and development of geotourism. Despite that, knowledge of geodiversity in Montenegro needs further progress and promotion. One of the future objectives is creation of the official inventory of geheritage objects. Systematic research of the Case study area by authors has resulted in an inventory of four objects: estavelle Gornjepoljski vir, karst spring Vidov brook, hill Trebjesa and slope Slivlje. Suggested inventory represents only the basis for further research which can contribute to the promotion of eco- and geo-tourism in the area.

Development of universal evaluation method is very difficult owing to the diversity in geomorphological environment (Pereira, Pereira, 2010). In this paper, objects were evaluated according to the scientific, aesthetical, ecological and morphometric criteria, and potential threat of natural processes which can harm physical state of landscape. As a result of evaluation, geoheritage map was presented with account of above mentioned criteria.

#### References

- Durović, Mijović, 2006 – Đurović, P., Mijović, D. (2006). Geonasleđe Srbije – reprezent njenog ukupnog geodiverziteta, *Zbornik radova – Geografski fakultet Univerziteta u Beogradu*, LIV, 5-18.
- Durović, Đurović, 2010 – Đurović, P., Đurović, M. (2010). Objekti geonasleđa – reprezenti geodiverziteta Crne Gore, *Međunarodni simpozijum Geoekologija XXI vek – teorijski i aplikativni zadaci, Žabljak*, 508-517.
- Radojičić, 2015 – Radojičić, B. (2015). Crna Gora, *Geografski enciklopedijski leksikon*, Filozofski fakultet Nikšić, Nikšić, 510 str.
- Zhyrnov, 2015 – Zhyrnov, P. (2015). Geomorphosite assessment method of the karst landscapes by considering the geomorphological factors, *Geomorphologia Slovaca et Bohemica*, 2/2015, 7-19.
- Reynard, Coratza, 2007 – Reynard, E., Coratza, P. (2007). Geomorphosites and geodiversity: a new domain of reaserch, *Geographica Helvetica*, 62, 137-139.
- Serrano, Ruiz-Flano, 2007 – Serrano, E., Ruiz-Flano, P. (2007). Geodiversity: a theoretical and applied concept, *Geographica Helvetica*, 62, 3, 140-147.
- Pereira, Pereira, 2010 – Pereira, P., Pereira, D. (2010). Methodological guidelines for geomorphosite assessment, *Geomorphologie: reliefe, processus, environment*, 2, 215-222.
- Reynard et al., 2007 – Reynard, E., Fontana, G., Kozlik, L., Scapozza, C. (2007). A method for assessing the scientific and additional values of geomorphosites, *Geographica Helvetica*, 3/2007, 1-13.



[Pantić et al., 1998](#) – Pantić, N., Belij, S., Mijović, D. (1998). Geo-nasleđe u sistemu prirodnih vrednosti i njihova zaštita u Srbiji, *Zaštita prirode*, 50, 407-413.

[Moscicka, 2011](#) – Moscicka, A. (2011). GEOHeritage – gis based application for movable heritage, *XXIII International CIPA Symposium*, Prague, Czech Republic, 229-232.

[Pralong, 2005](#) – Pralong, J.P. (2005). A method for assessing the tourist potential and use of geomorphological sites, *Geomorphologie. Relief, processus, environment*, 3, 189-196.

[Reynard, 2005](#) – Reynard, E. (2005). Geomorphological sites, public polices and property rights, *Conceptualization and examples from Switzerland – In: II Quaternario*, 18, 1, 321-330.

[Wimbledon, 1996](#) – Wimbledon, W.A.P. (1996). National site selection, a stop on the road to a European Geosite list, *Geologica Balcanica, Special issue Geological Heritage*, BAN, 15-28.

[Wimbledon et al., 1998](#) – Wimbledon, W.A.P., et al. (1998). A first attempt at a geosite framework for Europe – an IUGS initiative to support recognition of world heritage and European geodiversity, *Geologica Balcanica, Special issue “Geological heritage of Europe”*, BAN, 5-8.

[Comanescu et al., 2013](#) – Comanescu, L., Nedelea, A., Dobre, R. (2013). Mapping geomorphodiversity. Case study – Bucegi MTS (The Southern Carpathians, Romania), *26-th International Cartographic Conference*, Dresda, Germania.