GEOMORPHOSITE ASSESSMENT METHOD OF KARST LANDSCAPES BY CONSIDERING THE GEOMORPHOLOGICAL FACTORS

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Karst landscapes always attract a lot of tourists all over the world due to the combination of the beautiful and enigmatical landforms with unique complexes of flora and fauna, intricate network of hydrological objects, caves and historical buildings. Today we have different examples of geomorphosite assessment, in which reflect scientific, educational, economical, conservational values of landscapes. However, there is some incompleteness in accounting of morphometrical indexes for touristical and recreational adaptation and in analysis of dangerous natural processes influence for non-hazardous sojourn of tourists. Presented method of geomorphosite assessment implies the accounting of existing estimation values with morphometrical characteristics of relief and extent determination of possible dangerous natural processes influence on the human physical state of health on the territory of karst landscapes. Method of creation of the assessment map of karst landscapes for touristical activity were presented with due account of above-mentioned geomorphological factors.

Key words: geomorphosite assessment method, tourism, geomorphological factor, karst

INTRODUCTION

Geomorphological features of natural systems highly impact the character of recreational activities, because the relief is the basic element of natural complex. Furthermore, the relief defines the recreational specialization of the territory and on occasions, it is the element of recreational system formation.

Karst landscapes are peculiar phenomena of the nature, which differ from others in availability of unique underground and surface forms of the relief, evolution of specific forms of biocenosis, characterized by complex structure of hydrologic network including rivers, lakes and springs. All those natural factors are characterrized by high level of attraction for different kinds of ecological and adventure tourism. Furthermore, karst landscapes are the most pronounced geomorphosites among other types of landscapes, which just means that they are geomorphological landforms that have acquired a scientific, cultural, historical, aesthetic and economic value due to human perception or exploitation (PANIZZA 2001). In accordance with last introductions, the geomorphosite assessment includes the accounting of scientific, educational, economical, conservation (basic), cultural, ecological and aesthetical (additional) values (KUBALÍKOVÁ 2013, PEREIRA et al. 2007). Some scientists take the view that geomorphosite assessment must include an analysis of potential threats (ZOUROUS 2007, BRUSCHI and CENDERO 2005, CORATZA and GIUSTI 2005, SERANO and GONZALEZ 2005). However, there is currently no differentiation in extent determination of possible dangerous natural processes influence on the physical state of tourists health for various kind of tourism on the territory of karst landscapes.

In existing geomorphosite assessment methods, morphometrical indexes are of minor importance, only some authors are playing an insignificant attention to the separate morphemetrical indexes in the tourist use structure (PRALONG 2005). In our point of view, morphometrical indexes of karst relief remain an important aspect for geomorphosite assessment, because they define visibility, attraction, variety and passability of the territory and constitute the microclimatic conditions of locality.

An absence of monitoring criteria of karst underground landforms ecological status usually resulting from an excessive touristical load remains the most serious problem.

Our introduction of geomorphosite assessment includes compilation of evaluative criteria of existing assessment methods with due ac-

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count of morphometrical indexes for touristical and recreational adaptation and in analysis of dangerous natural processes influence for non-hazardous sojourn of tourists and careful ecological attitude to geological heritage of the Earth.

THEORETICAL BACKGROUND

Geomorphosite assessment requires a morphometrical analysis of karst relief. According to the views now dominant presentation (BREDIKHIN 2004) such morphometrical indexes play a key role for geotouristical assessment: medium altitude of the surface, gradient of slopes, exposure of slopes, depth and density of relief ruggedness (**Tab. 1**).

Scientific value plays a key role in geomorphosite assessment. Based on the fundamental recreational-and-aesthetical geomorphological researches (PEREIRA et al. 2007, KUBALÍKOVÁ 2013, RYBÁR 2010, REYNARD et al. 2007, CORATZA and GIUSTI 2005, PRALONG 2005) the conclusion can be made that scientific value of relief assessment can be formulated as follows:

1) Integrity (state of conservation of the karst geomorphosite);
2) Representativeness (karst geomorphosite exemplarity);
3) Rareness (rarity of the karst geomorphosite with respect to a reference space);
4) Diversity (number of different partial features and processes within the karst geomorphosite);
5) Paleogeographical value (importance of the karst geomorphosite for the Earth history).

Aesthetical value of karst landscape is the most important stage of geomorphosite assessment. According to the last researches (LIKHACHEVA et al. 2002, KUBALÍKOVÁ 2013, ŠTRBA et al. 2015) aesthetical assessment of the karst geomorphosite as a natural object consists from such categories:

1) Uniqueness of landforms: a) by the genesis; b) by the form and geographical location;
2) Uniqueness of karst landforms surface appearance: a) dissimilarity on anything (fantastic plot); b) similarity to biological and architectural objects;
3) Architectonic – composition – combination of parts in one whole. Symmetry and variety of landforms;
4) Visibility: a) outside view; b) visual exposure of the landscape from the object;
5) Exoticism (contrast degree);
6) Expressiveness (expressiveness degree of landforms);
7) Attendant effects: a) sounds – quiet (noise of waterfall, surf, echo…) b) warmth – coolness; c) brightness; d) colour; e) illumination (at sunrise, sunset, by the light of the moon…);
8) Compatibility - combination with other elements of a landscape: with flora, fauna, hydroobjects, architectural objects;
9) Stability or mobility – the dynamics of geomorphological landscape;

Morphometrical index	Influence on touristical activity
Medium altitude	Defines visibility and attraction of the territory, existence of a visible variety of landscape and high-altitude zones. Informative and emotional and psychological effects are closely connected with visibility.
Density of relief ruggedness	Defines a variety and passability of the territory, transportation possibility of vacationers and service personnel. Defines the creation of the infrastructure connected with a recreation.
Depth of relief ruggedness	Defines a variety of a landscape, the review of the panorama, esthetic satisfaction from the relief, degree of passability and availability of the territory.
Gradient of slopes	Defines prime cost of recreational engineering constructions, passability of the territory. The quantity of solar energy and illumination of the relief depends on the gradient of slopes. These facts must be taken into consideration of recreational organization.
Exposure of slopes	Defines frequency of the relief with solar energy. The southern exposition slopes are the most comfortable for touristical activity in temperate climatic zones of the northern hemisphere. Completeness of a range of expositions allows to choose areas of different function touristical activity for uneven-aged people.

Tab. 1 Characteristic of main morphometrical indexes for geomorphosite assessment (Modified after BREDIKHIN 2004)

Kind of tourism	The character of natural danger	Types of accidents and traumas
Backpacking	Billowy relief, mudflows, rockfalls, failures	Attritions,sprains, bruises, fractures
Mountaineering	Rockfalls, screes, mudflows, avalanches, failures, glacial accumulation, solar radiation, sharp change of meteoconditions, orientation loss	Fractures, bruises, frostbites, diseases of eyes, wounds by sharp objects
Wintry	Billowy relief, avalanches, rockfalls, failures, breaks of snow eaves, nivation	Bruises, fractures, death from asphyxia in an avalanche, frostbites, SARS
Speleological	Orientation loss, specific microclimatic conditions, collapses, failures, failures of the carbonate rocks roof, glacial accumulation	Wounds, bruises, concussions, immunity easing, infectious diseases

Tab. 2 Typical geomorphological dangers and accidents, characteristic for different kinds of ecological and adventure tourism in the karst landscapes (Modified after SHTURMER 1983)

10) Pictorializm – photogenicy (the favourite object of painters, photographers);
11) Emotional perception: a) admiring; b) worship; c) feeling of privacy; d) feeling merge to the nature;
12) Ethnic and social significance (international, national importance of object).

Aesthetic assessment of landscape complexes represents a relatively difficult problem. There are more score methodologies of landscape complexes aesthetic assessment, but there is no single decision about this procedure. By analyzing plural aesthetical-and-geographical researches (ERINGIS 1975, FROLOVA 1994, SUPRUNENKO 2003, DIRIN and POPOV 2010) the following criteria should be emphasised:

1) Contrast of landscapes (variety of structural-and-substantial heterogeneous complexes) – contrast appears in the zones of exertion (ecotones). Ecotones are transitional zones of different landscapes, which consist not only from contrast, but they also have an attractive effect (increasing of flora and landforms variety);
2) Colour spectrum of the landscape;
3) Depth of aspectual prospect;
4) Availability of hydrological objects in landscape structure and their quality and quantity;
5) Amount of forest;
6) Degree of anthropogenic transformation of natural landscapes;
7) Availability of symbolic objects in the landscapes.

Ecological value includes the level of protection of the karst area according to environmental legislation, level of relationship of geomorphological features with unique flora and fauna (PEREIRA et al. 2007) and environmental status of karst caves. From one side ecological status of karst caves has a very important influence on the attraction level of natural sight. From another side an abundance of tourist presents a serious problem for sensitive karst landscapes. Monitoring of environmental status (ANDREYCHUK 2007, TROFIMOVA 2012) of the karst caves need to be done with due account of such indexes of underground relief violation:

1) Anthropogenic variation of the relief:
a) change of the underground cavity size, creation of an artificial entrance to the cave, re-equipment of the natural entrance, carrying out tunneling works on expansion of the underground cavity size;
b) deformation of cave deposits: aqueous and chemical (damage or elimination of stalactites, stalagmites, corallites, etc.), vestigial (capping of geological and archaeological dug pits); cave ice (damage or destruction of long-term ice formations;
c) existence of metal, wooden artificial constructions (stairs, etc.).
2) Anthropogenic garbage:
a) food waste, grocery container and the used equipment;
b) the mold formed in the lower parts of underground cavities after touristic visits;
c) graphic elements drawing on walls and ceilings of caves.
3) Changes of the air environment of caves need to be fixed on existence of unpleasant smells of putrefaction, mold or evaporations of oil products.

Absolute safety of tourist during their excursions or backpacking is one of the most im-

Scientific value	Short characteristic	Points
Integrity (state of conservation of the karst geomorphosite)	Highly damaged as result of human activities or natural processes	0 points
	Damage but preserving essential geomorphological features	1 point
	Slightly damaged but still maintaining the essential geomorphological features	2 points
	No visible damage	3 points
Representativeness	Low representativeness and without pedagogical interest	0 points
	With some representativeness but with low pedagogical interest	1 point
	Good example of processes but hard to explain to non experts	2 points
	Good example of processes and good pedagogical resource	3 points
Rareness	More than 5 occurrences	0 points
	Between 3 to 5 occurrences	1 point
	2 occurrences	2 points
	The only occurrence	3 points
Diversity	1	0 points
	2	1 point
	3	2 points
	More than 3	3 points
Paleogeographical value	Absence	0 points
	Low value	1 point
	Weighty value	2 points
	Important value	3 points

Tab. 3 Numerical assessment of the geomorphosite indicator "scientific value" (Modified after PEREIRA et al. 2007)

portant conditions for realization of recreational activity in the territory of any landscapes. It would therefore be necessary to take account during geomorphosite assessment existing dangerous natural processes that will have a negative influence on the physical health state of the tourists (**Tab. 2**). There are such the most frequent dangerous natural processes in the territory of karst landscapes: failures of the carbonate rocks roof, rockfalls, screes, mudflows, avalanches, intensive erosion, corrosion, nivation, glacial accumulation. (SHTURMER 1983).

ESTIMATION SCALES AND UNITS

Justification of estimation scales and units of assessed criteria is an important stage of geomorphosite assessment method of karst landscapes.

The method of scientific value geomorphosite assessment by P. Pereira could serve as a baseline for karst landscapes. But we propose to use a three-point scale dependent on its degree of manifestation (**Tab. 3**).

There is no single estimation scale for aesthetical criteria of karst relief assessment. As karst relief is leading among others components of karst landscape, we propose following: each aesthetical criterion would be estimated for tourism development regarding a three-point scale. In order to realize aesthetical assessment of karst relief, we suggest to classify sculptures and underground relief of karst landscapes (VAKHRUSHEV 2004) by morphological and morphographical criteria (**Tab. 4**).

On the basis of existed methodologies (FROLOVA 1994, DIRIN and POPOV 2010) the criteria of landscape complexes aesthetic assessment were determined (**Tab. 5**).

We propose to realize zoning of karst nature systems according to morphometrical criteria, considering the relief as recreational resource for medical rest and for sport tourism (**Tab. 6**).

The next task is the creation of estimation scale for ecological status description of karst caves. All factors of underground relief violation are measured by scoring system: absence – 3 points, weak intensity – 2 points, average in-

Morphology	Morphography	Esthetical criteria of karst landforms	Estimation scale
Simple	***Sculpture landforms***	1) Uniqueness of landforms; 2) Uniqueness of karst landforms surface appearance; 3) Architectonic – composition; 4) Visibility; 5) Exoticism; 6) Expressiveness; 7) Attendant effects; 8) Compatibility; 9) Stability or mobility; 10) Pictorializm – photogenicy; 11) Emotional perception; 12) Ethnic and social significance	3 points – high level; 2 points – average level; 1 point – low level; 0 points – absence
Limestone pavements: grooved, meandering striated lanule wall crumbling interstratal channeled	narrow grooves furrows, lanule and cylindrical cavities		
Sinkholes	symmetrical conical dish-shaped asymmetrical with steep boards		
Moats	hollows extended on considerable distance with steep boards		
Grottos	niches in breaks		
Arches	arches of various configuration		
Hollows	the extended hollows		
Complicate	***Sculpture landforms***		
Lobes	dish-shaped asymmetrical, sometimes with steep boards		
Blind gullies	gullies falling into sinkholes		
Valleys	valleys, divided by hollows		
Tuff terraces	terraces near the karst springs		
Lakes	steeply hollows		
Simple	***Underground landforms***		
Sinkhole wells	conical cylindrical slit-like asymmetrical		
Pits	cylindrical slit-like asymmetrical		
Inclined and subhorizontal caves	inclined planes and subhorizontal galleries, courses divided by halls of various form		
Complicate	***Underground landforms***		
Cascade pits	alternation of internal pits and wells with short inclined courses		
Cave systems	large systems uniting everything morphological types of cavities		

Tab. 4 Morphological classification of the karst relief, its aesthetical criteria and estimation scale (modified after VAKHRUSHEV 2004)

№	Aesthetical criteria of landscape attraction		Points
1.	Contrast of landscapes - variety of structural-and-substantial heterogeneous complexes (SSC)	Landscape consists of 1-2 SSC	0
		Availability of 2-4 SSC by areal advantage 1 – 2	1
		Landscape includes more 4 SSC with dominant of 3 – 4	3
		Equal unit weight of squares more than 5 SSC	2
2.	Colour spectrum of the landscape	Black, dark grey	0
		Light grey, brown, pale-yellow	1
		Blue, green	2
		Blue, green with contrast manifestation (additional colours) – yellow, white, orange, red	3
3.	Depth of aspectual prospect	Absence	0
		Frontal	1
		Volumetrical	2
		Deep-spatial	3
4.	Availability of hydrological objects (lakes, rivers, springs) in landscape structure and their quantity	Absence	0
		1 object	1
		2 objects	2
		3 or more objects	3
5.	Degree of anthropogenic transformation of natural landscapes	Virgin landscape	3
		Cultural landscape	2
		Less modified landscape	1
		Damaged landscape	0
6.	Amount of forest, %	0	0
		1-15	1
		16-30	2
		30-60	3
		61-85	2
		>85	1
7.	Availability of symbolic objects in the landscapes	Absence	0
		1 object	1
		2 objects	2
		3 or more objects	3

Tab.5 Estimation scale of aesthetical landscape value (modified after FROLOVA 1994, DIRIN and POPOV 2010)

Absolute altitude (m)		Gradient of slopes (°)		Depth of relief ruggedness (m)		Density of relief ruggedness (km)	Points
rest*	tourism**	rest*	tourism**	rest*	tourism**		
>1500	0-500	>45; 12-45	0-3; 3-6	>800	<300	>2,5	0 points
1000-1500	500-1000	6-12	6-12	600-800	300-600	2,5-1,2	1 point
500-1000	1000-1500	3-6	12-45	300-600	600-800	1,2-0,8	2 points
0-500	>1500	0-3	>45	<300	>800	<0,8	3 points

*- medical rest; ** - sport tourism

Tab. 6 Zoning of karst nature systems according to morphometrical criteria for recreational adaptation

Indexes of underground relief violation	Kinds of violation	Estimation scale
Anthropogenic variation of the relief	Change of the underground cavity size, creation of an artificial entrance to the cave, re-equipment of the natural entrance, carrying out tunneling works on expansion of the underground cavity size	Absence – 3 points; Weak intensity – 2 points; Average intensity – 1 point; Significant intensity – 0 points
	Deformation of caves deposits: aqueous and chemical (damage or elimination of stalactites, stalagmites, corallites, etc.), vestigial (capping of geological and archaeological dug pits); cave ice (damage or destruction of long-term ice formations	
	Existence of metal, wooden artificial constructions (stairs, etc.)	
Anthropogenic garbage	Food waste, grocery container and the used equipment	
	The mold formed in the lower parts of underground cavities after touristic visits Graphic elements drawing on walls and ceilings of caves	
Changes of the air environment of caves	Existence of unpleasant smells of putrefaction, mold or evaporations of oil products	

Tab. 7 Estimation scale of karst landscapes ecological status (modified after ANDREYCHUK 2007, TROFIMOVA 2012)

tensity – 1 point, significant intensity – 0 point (**Tab. 7**).

Karst landscapes are characterized by streaming of different dangerous natural processes that there are the reasons of accidents during excursions or campaigns. Before preceding the assessment of natural processes influence on the tourists physical state of health, we propose to get definition for catastrophical and dangerous negative processes. According to the environmental geomorphology concept (STETSYUK et al. 2010), catastrophical processes refer to processes, which present direct serious danger for health and existence of human and characterized by vagueness of the moment of an appearance and intensity of manifestation. There are such possible catastrophical processes on the territory of karst landscapes: earthquakes, landslides, avalanches, rockfalls, mudflows, and screes. Dangerous processes affect on abiotic ecosystem component and only implicitly through on the flora, living organism and human due to changes or destruction of abiotic component. Karst processes relate to dangerous processes, because it has a very important influence on the stability of significant recreational buildings against to failures of the carbonate breeds roof, dissolution of carbonate rocks, and aggressive action of karst groundwater on the building units. Overcooling and overheating relate to negative medical processes which temporary disturb the normal physiological status of the human on the conditions of failures to comply with rules of sojourn in sunlight (on the peaks) and in caves (**Tab. 8**).

STAGES OF ASSESSMENT

The assessment procedure consists of ***three stages:***

1) Field survey;
2) Cameral work;
3) End-point geomorphosite assessment of karst landscape

Field survey. To fix dangerous places for tourist on the karst mountain range territory it is required to realize reconnoitring routes. To realize this aim it is required to use GPS navigator during the reconnoitring routes, which will fix the "points" of dangerous processes manifestation with their simultaneous description in the field journal. Using GPS navigator during the field survey, we can calendar unique sculpture and underground landforms to the above mentioned twelwe criteria. The location of unique landforms is colored by the GPS navigator. Given marks of each landform will be put in the field journal. The main caves should have eco-

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

Tab. 8 Estimation scale of possible dangerous natural processes influence on the physical state of health characteristic for karst landscapes

logical examination on basis of point system to the following characteristics: 1) anthropogenic variation of relief; 2) anthropogenic garbage; 3) changes of the air environment of caves. The aesthetical characteristics of landscape value and scientific values of geomorphosites should also be documented. The data about character of landscape value should be recorded in the field journal according to specified seven criteria, scientific value – according to specified five criteria. All points of landscape value and geomorphosites scientific value description are fixed with the GPS navigator.

Alternatively, existing landscape maps can be used for description of structural-and-substantial heterogeneous complexes of the karst mountain range. More correct estimation of this position is needed to take information from geomorphological and geobotanical maps of research territory.

Data collection. The capacity to gather a lot of cartographical materials on the karst mountain range (topography maps 1:10 000 or 1:25 000, aerial mapping, earth remote sensing/ ERS) should play a key role in the beginning of cameral work. Some part of this material is available on the cartographical websites. The remaining parts all involve a trip back to the cartographical funds or to specialized land-surveying agencies. All collected paper cartographic materials will be transferred to an electronic form.

Detailed digitization of the relief elements from topographical maps is next step of cameral work. The main result of the morphometrical operation is creating 3D terrain model and derived maps for analyzing medium altitude of the surface, gradient of slopes, exposure of slopes, depth of relief ruggedness, density of relief ruggedness.

Next, layers of sculptures and underground karst landforms are ployed on the digital surface of the karst landscape. For realization of this step besides of data from field survey and existing geomorphological maps, we can use analyses of photointerpretation and ERS (earth remote sensing) materials. Overlaying of points of aesthetical assessment of karst landforms from the GPS navigator is the next operation. The information concerning this layer is received from the field journal. The same operations need to be done with points of landscape, scientific values description and points of assessment of karst landscapes ecological status. Description of points of dangerous processes manifestation is based on GPS data and also contains analyses of photointerpretation and ERS (earth remote sensing) materials.

End-point geomorphosite assessment of karst landscape. Our final step is geomorphosite assessment of karst landscape in the allocation of following sites on the corresponding map: a) unfavourable sites for tourism; b) restrictedly favourable sites for tourism; c) favourable sites for tourism; d) especially valuable sites for tourism. For this aim we propose to create such cluster of geotouristical assessment data in the specialized ArcGIS ArcMap software product:

1) Scientific cluster. In this cluster each geomorphosite need to be evaluated according to seven scientific criteria present within an area of 1 km². To form the final scientific cluster, one should prescribe the mean arithmetical value for the each cell. Graphically

this cluster would look like empty polygon with picture filling inside.

2) Aesthetical geomorphological cluster. In this cluster karst landforms need to be evaluated according to twelve criteria present within an area of 1 km². To form the final aesthetical geomorphological cluster, one should prescribe the mean arithmetical value for the each cell. Graphically this cluster would look like multi-colored contours without internal filling.

3) Aesthetical landscape cluster includes the assessment of aesthetical landscape value regarding to above-mentioned seven criteria. To form the final aesthetical landscape cluster, one should prescribe the mean arithmetical value for the each cell. Graphically this cluster would look like polygonal filling without allocation of contours.

4) Morphometrical cluster. Each morphometrical index would be estimated for final result regarding a three-point scale. To form the final morphometrical cluster, one should prescribe the mean arithmetical value for the each cell. Graphically this cluster would look like multi-textural contours without internal filling.

5) Ecological-and-geomorphological cluster. In this cluster caves need to be evaluated according to three criteria, present within an area of 1 km². To form the final ecological-and-geomorphological cluster, one should prescribe the mean arithmetical value for the each cell. Graphically this cluster would look like multi-textural hatch.

6) Natural hazards cluster involves the extent determination of possible dangerous natural processes influence on the physical state of health. We also plan to use 3-point scale, depended on the extent of the danger of natural geomorphological processes. To form the final natural hazards cluster, one should prescribe the mean arithmetical value for the each cell. Graphically this cluster would look like empty polygon with picture filling inside.

7) End-point geomorphosite assessment map of the karst landscape. There are six shapes with attribute data in each of received clusters. Our final step is assessment of geotouristic potential of the karst landscape in the allocation of: a) unfavourable sites for tourism (0-4 points); b) restrictedly favourable sites for tourism (5-8 points); c) favourable sites for tourism (9-13 points); d) especially valuable sites for tourism development (14-18 points) - **Tab. 9**. We should use here coupled geoinformatical method. Each cell contains mean arithmetical value of assessed characterics in each of received cluster that need to be totalized. We'll have the final grid, which will be stated the final total in the result of six clusters overlaying. Unfavourable sites shall be painted with red colour (dark grey in printed version of **Tab. 9**) with a counter. Restrictedly favourable sites shall be painted with orange colour (very light grey in printed version) with a counter. Favourable sites shall be painted with blue colour (light grey in printed version) with a counter. Especially valuable sites shall be painted with green colour (medium grey in printed version) with a counter. To make the map more smoothly, it will be necessary to create a new shape file and to mark the points in the center of each total sum cell. It will be necessary to specify number of points equal to a total sum of points within each cell. The Kriging ordinary method is used to create the interpolated raster. The final interpolated raster of geomorphosite assessment is our main result, which will strike with the accuracy and brilliance.

CONCLUSION

Presented method of karst landscapes geomorphosite assessment is one of attempts to show the basic criteria that need to be noted in the definition of attraction level of unique surface features and of nonhazardous sojourn of tourists in the territory of karst mountain range. During the assessment the following goals were achieved:

– sculptures and underground landforms of the karst landscape were classified according to their morphological criteria for the geomorphosite assessment and geomorphological mapping;
– sculptures and underground karst landforms were evaluated according to the following aesthetical criteria: uniqueness of landforms, uniqueness of karst landforms surface appearance, architectonic – composition, visibility, exoticism, expressiveness, attendant effects, compatibility, stability/mobility, pictorializm – photogenicy, emotional perception, ethnic and social significance;
– aesthetical properties of the karst landscape were evaluated according to the following criteria: contrast of landscapes, colour spectrum of the landscape, depth of aspectual prospect, availability of hydrological objects, degree of anthropogenic transformation of natu-

acteristics	Especially valuable for tourism	Mark	Favourable for tourism	Mark	Restrictedly favourable for tourism	Mark	Unfavourable for tourism	Mark
Scientific cluster								
Integrity	No visible damage	3	Slightly damaged	2	Medial level of damage	1	Highly damaged	0
Representativeness	Good example of processes and good pedagogical resource	3	Good example of processes but hard to explain to non experts	2	With some representativeness but with low pedagogical interest	1	Low representativeness and without pedagogical interest	0
Rareness	The only occurrence	3	2 occurrences	2	Between 3 to 5 occurrences	1	More than 5 occurrences	0
Diversity	More than 3	3	3	2	2	1	1	0
Palaeogeographical value	Important value	3	Weighty value	2	Low value	1	Absence	0
Aesthetical geomorphological cluster								
Uniqueness of landforms	High level	3	Average level	2	Low level	1	Absence	0
Uniqueness of karst landforms surface appearance								
Architectonic- composition								
Visibility								
Exoticism								
Expressiveness								
Attendant effects								
Compatibility								
Stability/mobility								
Pictorializm-photogenicy								
Emotional perception								
Ethnic and social significance								
Aesthetical landscape cluster								
Contrast of landscapes - variety of SSC	Landscape includes more 4 SSC with dominant of 3-4		Equal unit weight of squares more than 5 SSC	2	Availability of 2-4 SSC by areal advantage 1-2	1	Landscape consists of 1-2 SSC	0
Colour spectrum of the landscape	Blue, green with additional colours	3	Blue, green	2	Light grey, brown, pale-yellow	1	Black, dark grey	0
Depth of aspectual prospect	Deep-spatial	3	Volumetrical	2	Frontal	1	Absence	0
Availability of hydrological objects	3 or more objects	3	2 objects	2	1 object	1	Absence	0
Degree of anthropogenic transformation	Virgin landscape	3	Cultural landscape	2	Less modified landscape	1	Damaged landscape	0
Amount of forest, %	30-60	3	16-30/61-85	2	1-15/>85	1	0	0
Availability of symbolic objects	3 or more objects	3	2 objects	2	1 object	1	Absence	0

Tab. 9 Geomorphosite assessment method of the karst landscape (in printed version: medium grey = green (col. 2 and 3); light grey = blue (col. 4 and 5); very light grey = orange (col. 6 and 7); dark grey = red (col. 8. and 9)

Morphometrical cluster								
Absolute altitude of relief, m	>1500	3	1000-1500	2	500-1000	1	0-500	0
Gradient of slopes, °	>45	3	12-45	2	6-12	1	0-6	0
Depth of relief ruggedness, m/km²	>800	3	600-800	2	300-600	1	<300	0
Density of relief ruggedness, km/km²	<0,8	3	1,2-0,8	2	2,5-1,2	1	>2,5	0
Ecological-and-geomorphological cluster								
Anthropogenic variation of the relief Anthropogenic garbage Changes of the air environment	Absence	3	Weak intensity	2	Average intensity	1	Significant intensity	0
Natural hazards cluster								
Index of natural processes' danger	Absence		Negativeprocesses		Dangerousprocesses		Catastrophicprocesses	
Kinds of dangerous processes	-	3	Overcooling	2	Failures	1	Earthquakes	0
			Overheat	2	Dissolution of car-bonate rocks	1	Landslides	0
							Avalanches	0
					Aggressive action of ground waters	1	Mudflows	0
							Screes	0

Tab. 9 Geomorphosite assessment method of the karst landscape (continue)

ral landscapes, amount of forest, availability of symbolic objects;

– ecological-and-geomorphological criteria of environmental status of the karst caves were presented due account of such indexes of underground relief violation: anthropogenic variation of relief, anthropogenic garbage, changes of the air environment of caves;
– estimation scale of possible dangerous natural processes influence on the physical state of health characteristic for karst landscapes were presented;
– stimated ranging system of the morphemetrical characteristics of the karst landscape in the degree of their usefulness for medical rest and sport tourism was created;
– method of creation of the geomorphosite assessment map of the karst landscape was presented with due account of above mentioned assessed criteria.

However, the accounting of cultural and economic values for more complete geomorphosite assessment of karst landscapes and progress in method of the end-point assessment calculation are still required in the allocation of sites suitability degree for tourism. Also, the discussion about expansion of the morphometrical assessed criteria and quantity minimization of aesthetical criteria of landscape attraction for the simplicity of the geomorphosite assessment realization is possible. It is an aim of nearest researches to which all interested specialists are welcome.

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