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Methodological guidelines for geoh heritage site assessment: a proposal for Serbia

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Abstract: Various minerals, rocks, soil types, ore and fossiliferous deposits, structural and tectonic elements, surface and subterranean landforms, all those natural phenomena representing geodiversity in a small scale contribute to our understanding the significant events and episodes of the geological history of the Earth. Intended methodology for qualitative and quantitative assessment is presented, including valuing criteria and their numerical indicators, which serve as analytical instruments to identify and select potential geoh heritage objects in Serbia. Objective assessing and categorizing the geoh heritage objects are the starting points for their rational utilization, adequate conservation, proper interpretation and promotion.

Key words: geodiversity, geoh heritage, geoparks, methodological guidelines, assessment, Serbia.

Апстракт: Разноврсни минерали, стене, типови земљишта, рудна и фосилоносна налазишта, структурни и тектонски елементи, површински и подземни облици рељефа, сви ови природни феномени представљајући геодиверзитет „у малом“, доприносе нашем разумевању значајних догађаја и епизода из геолошке историје Земље. Осмишљена је и у раду приказана методологија за квантитативну и квалитативну процену, укључујући вредносноне критеријуме и одговарајуће нумеричке параметре који, као аналитичка средства, служе да се идентификују и издвоје потенцијални објекти геонаслеђа у Србији. Објективна процена и категоризација објеката геонаслеђа полазне су основе за њихово рационално коришћење, примену адекватних мера заштите, одговарајућу интерпретацију и промоцију.

Кључне речи: геодиверзитет, геонаслеђе, геопаркови, методолошке смернице, процена, Србија.

Introduction

The term geodiversity first appeared in a Tasmanian Forest Commission document, intending to describe the diversity of Earth's features and systems (SHARPLES 1993). Geodiversity is defined as the variety within the entire abiotic world that encompasses the natural range of geological, geomorphological and soil features, assemblages, systems and processes (AUSTRALIAN NATURAL HERITAGE CHARTER 2002). It also includes evidence of the history of the Earth (evidence of ancient life, paleoecosystems, and paleoenvironments) and a range of relict and active biological, hydrological and atmospheric processes.

There is no doubt that many geodiversity phenomena are mainly endangered by humans neglect, mismanagement, overexploitation and unplanned con-

struction. Geodiversity is so diverse that is difficult to decide which phenomena should be protected and preserved. Regarding the fact that is overall geodiversity is impossible to conserve, it is necessary to recognize those phenomena that are scientifically, educationally, culturally and economically explored and valuable. Geoh heritage is the representative part of geodiversity that may be specifically identified as having conservation significance.

The geodiversity and geoh heritage phenomena are finite and the principles of sustainable development advise wise use of these resources for the sake of future generations who might also want to use them (MARAN 2008). Geoconservation involves a set of actions focus on protecting, conserving, presenting and promoting the geodiversity and geoh heritage for their intrinsic, ecological and heritage values. Beside

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the preventive protection, geoconservation also includes development and improvement in the field of scientific and professional research, legislation, education, spatial and urban planning and tourism (MARAN STEVANOVIĆ 2014).

Geoeducation plays an important role in promoting geoheritage values, in order to gain support for the implementation of geoconservation objectives and to ensure effective practical management of geoheritage (MARAN 2012, unpublished doctoral thesis). Geotourism is recognized as new form of tourism, which original reason for developing is to promote an understanding of earth sciences, tourism to geosites and the conservation of geodiversity through appreciation and learning (HOSE 2000, NEWSOME & DOWLING 2010, FARSANI *et al.* 2011). All these aspects are incorporated within the Geopark concept (ZOUROS & MARTINI 2003, EDER 2004, MC KEEVER & ZOUROS 2005) (Fig. 1). Establishment of geoparks, the European Geoparks Network (EGN) and the Global Network of National Geological Parks (GGN) was one of the most important international initiatives in the field of geoconservation. Synergy of geodiversity, biodiversity and cultural heritage is the basis for the functioning of each geopark; educational activities are primarily oriented towards exploring the integrity of natural and cultural heritage through development of geotourism in order to provide a wide range of employment opportunities to the local population and to stimulate economic development of the region (MARAN STEVANOVIĆ 2014a).



Fig. 1. Spectacular dolomites of the Brenta Group, Geopark Adamello Brenta, an open geological laboratory for appreciation and learning (photo: A. Maran Stevanović).

Importance of geodiversity and geoheritage

Study of geodiversity and geoheritage develops different scientific methods and procedures to identify

features, processes, sites and specimens that have nature conservation values (MARAN 2012a). Identification, registration and evaluation of geodiversity and then selection and conservation of valuable geoheritage sites and objects are complex tasks which require good background knowledge in the field of geosciences, multidisciplinary approach, scientific analysis and application of various methodologies and principles.

The definition of guidelines to manage geodiversity assessments and register geoheritage sites and objects were among the main geoconservation aims in different countries (MARAN 2010 and references herein). However, diverse national geoheritage contexts and objectives have not allowed the development of universal guidelines (PEREIRA & PEREIRA 2010). Consequently, many experts and researchers have proposed various methodological procedures based on different characteristics of geoheritage objects (JOYCE 1994, WILSON 1994, WIMBLEDON *et al.* 1995, WIMBLEDON 1998, DOYLE & BENNET 1998, ALCALA 1999, PEMBERTON 2001, SHARPLES 2002, GREY 2004, BRUSCHI & CENDRERO 2005, WHITE & MITCHELL 2006, PEREIRA *et al.* 2007, ZOUROS 2007, REYNARD *et al.* 2007, REYNARD 2008, BROCX 2008, CARCAVILLA *et al.* 2009, PENA DOS REIS & HENRIQUES 2009, PEREIRA & PEREIRA 2010, FASSOULAS *et al.* 2012). In general, the combined values that arise from geodiversity can be classified into five main categories (MARAN 2012):

1. Intrinsic
2. Ecological
3. Economic
4. Cultural
5. Research and educational.

1. The concept of **intrinsic value** means that Earth possesses and phenomena may have value beyond the social, economic or cultural values held by humans (SHARPLES 2002). In nature conservation, this concept is widely accepted but it is very difficult to justify since it involves ethical and philosophical dimensions of the relationships between humans and nature (GRAY 2004).

2. Ecosystems depend entirely on their non-living parts such as bedrock, landforms and soils that are habitats of animals and plants. In this sense, the **ecological value** of geodiversity refers to its importance in sustaining geological, geomorphologic and soil processes as well as biological processes, which depend upon those systems.

3. Rocks, minerals and fossils, all have **economic value**. Varied rocks and minerals are essential as they supply humans with mineral fuels (e.g. petroleum and coal), industrial metallic and precious minerals (ores and gemstones) and construction materials (aggregates and building stone) (GREY 2004). Fossils also have significant commercial value, particularly if they are well preserved and well known (e.g. dinosaur' fos-

sils, ammonite, trilobite or rudist “jewelry”, fossiliferous ornamental stones, etc.).

4. The **cultural value** of geodiversity implies the significance placed by global society on some aspect of physical environment, such as mythology, archeological-historical, spiritual and aesthetic value (e.g. Lepenski Vir archeological site, NP Djerdap, eastern Serbia, Fig. 2).



Fig. 2. Lepenski Vir archeological site and museum, included in the UNESCO World Heritage List (photo: A. Maran Stevanović).

5. Georesources have important **research and educational values**. Geological features illustrate the huge periods of time they took to form the natural resources on which today’s society depends. They are rich in evidence of changing climates, shifting boundaries between continents and oceans and extinction events. Rock exposures, landforms and soils, all they can provide *in situ* polygons for training of the new generation of geologists, geomorphologists, pedologists, amateurs and children.

The assessment of geoheritage sites in Serbia

The Serbian LAW ON CULTURAL PROPERTIES (71/1994) recognizes the two large categories of the national cultural and natural legacy: the non-moveable (*in situ*) and the moveable (*ex situ*). Following that general classification, the non-moveable heritage may correspond to the geosites with clearly pronounced geological, geomorphologic or pedological features whereas particular rock, ore and mineral samples as well as fossil specimens represent moveable geoheritage objects (MARAN 2005). In detail, the components that should be recognized as geoheritage include (MARAN 2012):

- Igneous, metamorphic and sedimentary rocks and their processes of formation;

- Mineral resources (minerals and mineralization), mines and quarries;
- Structural and tectonic features on different scales;
- Fossils and fossiliferous sites;
- Stratigraphical contacts;
- Relict and active landforms and their forming processes;
- Relict and active hydrogeological features;
- Relict and active soils and soil forming processes;
- Building stones and related products.

In Serbia, prior to 1995, 75 geoheritage objects were protected based on sporadically given individual proposals, including 73 geosites and 2 moveable geological objects (source: INSTITUTE FOR NATURE CONSERVATION OF SERBIA, personal communication 2014). Except geomorphological, hydrogeological and rare fossiliferous localities, other sites have only named “officially protected”, without adequate geoconservation measures and actions. The project “Inventory of the geoheritage sites of Serbia”, initiated by the Serbian National Council for Geoheritage Conservation in 1996, was aimed to collect proposals for geosites that mark important events in the geological history of Serbian territory. The work on the inventory was undertaken between 1996 and 2003 and in 2004 preliminary list has been created. It includes 552 geosites proposed for conservation; they are classified into eleven categories according to recommendations of the European Association for the Conservation of the Geological Heritage (ProGEO). In Serbia, the establishment of comprehensive National geoconservation strategy is still missing despite many warnings from specialists. Prior to define the strategy, however, many researches should take place, including preliminary selection of important geodiversity sites, valuing geodiversity, assessing potential threats, and identifying general actions to prevent or enhance significant geoheritage features (MARAN 2012a).

The choice of criteria for judging the value and significance of geodiversity for geoconservation is considered the first stage in any assessment. During the last two decades, several attempts have been done to develop appropriate criteria for identification and selection of potential geoheritage objects in Serbia. Prior to 2000, most researchers have proposed different geosites for inventory based mainly on their subjective observations and field experiences or simply applying the ProGEO recommendations (MIJOVIĆ & MILJANOVIĆ 1999), which intended to serve only as guidelines not as clearly defined principles. In recent years, some authors offer improved approach to assessment of geoheritage objects aimed at scientific, educational and tourist valorization and promotion, including qualitative and quantitative evaluation (STANKOVIĆ 2004, MARAN 2010, TOMIĆ 2011, MARAN STEVANOVIĆ 2014, VIŠNJIĆ & BEGAN 2015).

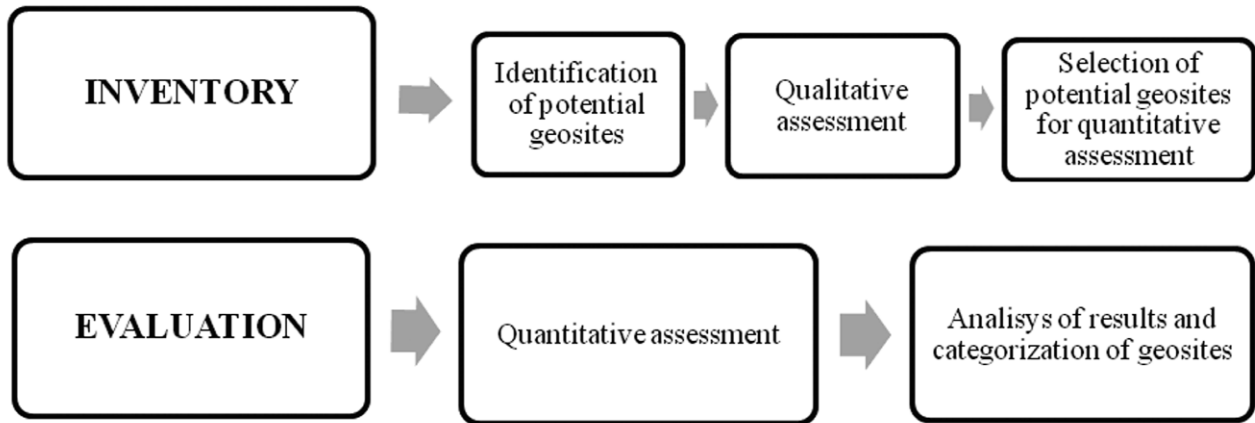


Fig. 3. Stages in geosite assessment.

As a member of the Working group for the establishment of potential Djerdap geopark in eastern Serbia, appointed by the Serbian Ministry of Natural Resources, Mining and Spatial Planning, the author of this paper was asked to prepare a set of qualitative and quantitative parameters in order to estimate the geodiversity potential within the area of National Park Djerdap and its vicinity (MARAN STEVANOVIĆ 2013, unpublished report). These starting indicators are used to develop methodology for the quantitative and qualitative assessments of geosites that should support geoconservation and management of geoh heritage sites within potential geopark area. Adapting the methodologies and procedures suggested by REYNARD *et al.* (2007), REYNARD (2008) and PEREIRA & PEREIRA (2010) to our circumstances and objectives, the two main stages are taken into consideration, the inventory and evaluation with corresponding substages (Fig. 3). The inventory includes: 1) identification of potential geosites, 2) qualitative assessment of potential geosites and 3) selection of geosites for quantitative assessment. The evaluation phase involves two substages: 1) quantitative assessment of selected geosites, and 2) analysis of results and categorization (ranking) of geosites.

Operating criteria used to evaluate and quantify geodiversity values as well as to choose potential geoh heritage sites are presented. Some basic criteria have been explained previously (MARAN 2005, 2008, 2010)

whereas “new” ones are designed for particular case. They are divided into four groups, including scientific value (SV), other (additional) values (OV), functional values (FV) and vulnerability of sites (VU) (Table 1). Each category has its final score and the total value (TV) will be reached by algorithm (MARAN STEVANOVIĆ 2014b):

Total value

$$(TV) = (3 \times SV) + (2 \times OV) + (2 \times FV) + (2 \times VU) / 2,5$$
maximum number of points = 100

The criterion scientific value (SV) of geoh heritage is the most important and includes several parameters for its designation such as uniqueness, representativeness, complexity, educative value and level of exploration (research).

Uniqueness (U) means that a phenomenon (mineralogical, petrological, paleontological, hydrogeological, geomorphological, pedological etc.) is the only one of that type within a spatial unit (continent, state) and represents the etalon for estimating values of all other phenomena (e.g. stratotype). Value and importance of such a phenomenon is universal. Representativeness (R) refers to the most complete representation of characteristics of a certain phenomenon. Out of various objects (mineralogical, petrologic, paleontological, hydrogeological, geomorphologic etc.) one is chosen if it illustrates nature and origin of a certain

Table 1. Criteria for evaluation of geoh heritage sites (MARAN STEVANOVIĆ 2014b).

Scientific value (SV)	Other values (OV)	Functional values (FV)	Vulnerability (VU)
Uniqueness Representativeness Complexity Educative value Level of exploration	Ecological Cultural Aesthetic	Accessibility Visibility Connection with other natural and cultural objects Infrastructure facilities Economic potential	Level of threat Level of preservation

phenomenon, form or process in the best (most complete) way. The complexity (**C**) of certain phenomenon means that its features have multipurpose character (e.g. a cave with specific cave ornaments, fossilized remains and prehistoric artifacts is, at the same time, the speleological, paleontological and archeological site). Educational value (**EV**) relates to the possibility of particular phenomenon to be used in affirmation, popularization and presentation of geology and geosciences, geodiversity and geoheritage. Level of exploration (**LE**) means amount of collected information about certain phenomenon obtained through literature, field data, personal experiences or oral communications. Each mentioned parameter has its numerical indicator (Table 2) and the final value is presented by the algorithm:

$$SV = (4 \times U) + (2 \times R) + C + (2 \times EV) + LE$$

(maximum number of points = 50)

Table 2. Parameters and their numerical indices used to estimate the scientific value of each geoheritage site.

Scientific value (SV)	Score
Uniqueness (U)	0 – absent
Representativeness (R)	1 – insufficient
Complexity (C)	2 – low
Educative value (EV)	3 – medium
Level of exploration (LE)	4 – high
	5 – very high

The second criterion implies **other values (OV)** of geoheritage viewed from ecological (**E**), cultural (**CU**) and aesthetic aspects (**A**) (Table 3). Ecological value of geosite represents its contribution to the interaction between biodiversity and geodiversity in the area (e.g. development of particular ecotype, existence of endemic plant or animal species). Geosite can contribute to the cultural identity of an area in different ways, including its historic perspective (connection of certain site with historic events and people), local religion, tradition and art. Aesthetic value refers to the site visual appearance and its possibility to attract observer attention. The algorithm shows the final value of certain parameters:

$$OV = E + CU + (2 \times A)$$

(maximum number of points = 20)

As geoheritage sites are most commonly promoted for tourism purposes, their **functional values (FV)** are also significant and comprise the following indicators (Table 4): a) accessibility (**AC**) (topography, distance from the main traffic roads, access to the object, presence of asphalt roads or pathways in the area); b) visibility (**V**); c) spatial connection (**SC**) with other

Table 3. Parameters and numerical indices of parameters used to estimate other values of each geoheritage site.

Other values (OV)	Score
Ecological (E)	0 – absent
Cultural (CU)	1 – insufficient
Aesthetic (A)	2 – low
	3 – medium
	4 – high
	5 – very high

important natural and cultural sites; d) infrastructure facilities (**IF**) (presence of infrastructure objects, services and products intended for visitors, e. g. accommodation, restaurants, shops, information centers, museums, walking tours, informative panels, maps, souvenirs) and e) economic potential (**EP**) (possibility of using sites for commercial purposes to gain profit). The final value is determined through the following algorithm:

$$FV = AC + V + SC + IF + (2 \times EP)$$

(maximum number of points = 20)

Table 4. Parameters and their numerical indices used to estimate the functional value of each geoheritage site.

Functional value (FV)	Score
Accessibility (AC)	1 – inaccessible
	2 – medium
	3 – good
Visibility (V)	1 – difficult to notice
	2 – medium
	3 – good
Spatial connection with other natural and cultural sites (SC)	1 – absent or weak
	2 – medium
	3 – good
Infrastructure facilities (IF)	1 – absent or minimal
	2 – medium
	3 – good
Economic potential (EP)	1 – absent or low
	2 – medium
	3 – high
	4 – very high

In order to choose appropriate conservation methods, it is necessary to assess the site **vulnerability (VU)**, which includes two indicators, the current level of threat (**LT**) and current level of preservation (**LP**) (Table 5). Threats to the integrity of geoheritage sites are numerous and can be grouped as natural or anthropogenic. The first category mainly relates to natural

degradation caused by erosion and weathering processes, landslides or vegetation growth. The second group of threats, although almost unintended, resulted from human activities including the expansion of urban areas, commercial quarrying, improper waste storage, inappropriate collecting and excessive tourist pressure (MARAN STEVANOVIĆ 2014). The final value will be reached through the following algorithm:

$$\mathbf{VU = LT + LP}$$

(maximum number of points = 10)

Table 5. Parameters and numerical values of parameters used to estimate the level of threat and level of preservation for each geoh heritage site.

Vulnerability (VU)	Score
Level of threat (LT)	0 – not threatened 1 – potentially threatened 2 – partially threatened 3 – threatened 4 – partially damaged 5 – highly damaged
Level of preservation (LP)	0 – very high 1 – high 2 – medium 3 – low 4 – very low 5 – not preserved

These qualitative and quantitative parameters have been used to test the categories of geoh heritage sites, previously proposed and discussed (MARAN 2010, 2012, 2012a). Accordingly, proposed numerical value for each category is:

- The category Internationally Important Geosites (IIG) includes sites with the total score that must be greater than 85 points. They have to satisfy the combination of three groups of classification criteria, including scientific, additional and functional values. In accordance to the current level of threat and current level of preservation, sites must be well preserved and not threatened (or potentially threatened only).
- The category Nationally Important Geosites (NIG) refers to sites with the total score between 75 and 85 points.
- The category Regionally Important Geosites (RIG) incorporates sites with the total score between 60 and 75 points.
- The category Locally Important Geosites (LIG) may include sites with total score between 40 and 60 points, but exclusively, the score of scientific value (SV) must be above 25 ($SV > 25$).

Qualitative and quantitative assessments are also tested in process of selection of potential geoh heritage sites in studied areas in eastern and western Serbia (Boljevac and Mokra Gora) (MARAN 2012). In addition to the verification of site rank, the evaluation of site value and significance helps to determine relevant measures for geoconservation, including physical protection, site monitoring and site preparation for visitors as well as different scientific, educational and cultural activities (e.g. establishment of georoutes). The application of quantitative (numerical) evaluation is important because it can minimize the assessor subjectivity. It is expected that proposed methodology for qualitative and quantitative assessments could be accepted by relevant authorities and put into practice.

Final remarks and recommendations

Based on our previous experience, it can be concluded that the researcher subjectivity dominated largely in the process of site selection and suggestion for conservation. Even today, most researchers obviously prefer their fields of expertise to considering objective and realistic proposals. These circumstances can be explained by the ignorance of basic standards and a limited access to existing literature and practice. This is the reason why more objective and quantitative analysis should be carried out.

Proposed methodology includes qualitative and quantitative assessments, which can serve as useful instrument to meet the needs for appropriate management and conservation of valuable geoh heritage sites in certain territory. It can reveal priorities for geosite conservation, development of geotourism and educational activities.

It is generally accepted that the selected geosites must be of top quality, complex in information, well-preserved, and the most representative in their group of phenomena. Consideration of the geoh heritage sites should be done through documentation, assessment and comparison, at international, national, regional and local levels. Site information must be reviewed on the basis of personal experience, fieldwork, literature and consultation with other geologists and geoscientists with specific knowledge and expertise. The significance rating assigned to the site must be periodically reassessed in light of new information and site condition. Precise, objective and detailed explanation should clearly indicate the site important characteristics and its possible functions.

The qualitative and quantitative assessment should become an integral part of the methodology of scientific and professional researches that implies: a) study on geodiversity of an area, b) qualitative evaluation and selection of potential geoh heritage sites, c) quantitative evaluation, d) assessment of the site condition and its vulnerability (level of threat and level of

preservation), and e) proposals for adequate conservation measures and activities aimed at popularizing, presentation and promotion of geosites.

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Резиме

Методолошке смернице за процену објеката геонаслеђа: пример из Србије

Појам геодиверзитет уведен је у научну и стручну литературу да би се описала разноврсност облика, појава и процеса у оквиру неживе природе и истакао њихов значај за настанак и развој живота на Земљи. Геонаслеђе чине репрезентативни феномени геодиверзитета, издвојени као посебне природне вредности од значаја за науку, образовање, културу или економију. Следећи смернице ЗАКОНА О КУЛТУРНИМ ДОБРИМА (71/1994) којим је регулисана заштита националне културне и природне баштине, објекти геонаслеђа груписани су у две основне категорије:

- Непокретни објекти геонаслеђа или геонаслеђе *in situ* су геолошки локалитети и профили, површински и подземни облици рељефа, различити типови земљишта.
- Геонаслеђе *ex situ* или покретни објекти геонаслеђа обухватају примерке стена, минерала, руда и фосила, који се након идентификације могу однети са локалитета или налазишта где су откривени ради научних и стручних истраживања.

На основу нашег досадашњег искуства може се закључити да у процесу селекције и предлагања објеката геонаслеђа који треба да се заштите у великој мери доминира субјективност предлагача. Очигледно је да чак и данас већина истраживача фаворизује оно чиме се бави, а не објективне и реалне предлоге. Овакво чињенично стање може се објаснити непознавањем основних принципа геозаштите и ограниченим увидом у постојећу литературу и праксу.

Значај и вредност објеката геонаслеђа утврђује се на основу свих прикупљених релевантних информација (преглед литературе и документације, теренски рад, консултације са стручњацима различитих специјалности, лично искуство) као и поређењем са сродним објектима на међународном, националном, регионалном и локалном нивоу. У својству члана Радне групе за оснивање потенцијалног геопарка Ђердап, источна Србија, од

аутора овог рада тражено је да предложи метод за процену значаја и вредности непокретних објеката геонаслеђа (геолошки локалитети и профили, површински и подземни облици рељефа, различити типови земљишта) на подручју постојећег Националног парка Ђердап и његове околине. Прилагођавајући методологије и процедуре које су дефинисали REYNARD *et al.* (2007), REYNARD (2008) и PEREIRA & PEREIRA (2010) нашим условима и потребама, издвојене су две основне методолошке фазе или етапе: инвентаризација и евалуација. Фаза инвентаризације састоји се од три подфазе: 1) идентификација потенцијалних непокретних објеката геонаслеђа, 2) квалитативна процена непокретних објеката геонаслеђа и 3) избор објеката за квантитативну анализу. Фаза евалуације обухвата две подфазе: 1) квантитативна процена објеката геонаслеђа и 2) анализа резултата и категоризација (рангирање) објеката.

Предуслов а уједно и полазна основа за евалуацију објеката је правилан избор критеријума, који служе као аналитичка средства да се из групе истоветних или сродних одабере објекат који најкомплетније илуструје одређени феномен. Издвојени су критеријуми за евалуацију, подељени у четири групе: научни значај (**НЗ**), друге вредности (**ДВ**), употребна вредност (**УВ**) и рањивост (**Р**) објеката. Сваки од критеријума има своје подкри-

теријуме или параметре као и одговарајуће нумеричке ознаке. Укупна вредност одређеног објекта (**УВО**) одређује се алгоритмом:

УКУПНА ВРЕДНОСТ

$$(УВО) = (3 \times НЗ) + (2 \times ДВ) + (2 \times УВ) + (2 \times Р) / 2,5$$

максимални број поена = 100

У функцији оперативних инструмената, наведени критеријуми предложени су као основ за идентификацију, евалуацију, селекцију и категоризацију потенцијалних објеката геонаслеђа не само на територији НП Ђердап већ и на било ком другом подручју у Србији. Препорука аутора је да квалитативна и квантитативна процена објеката геонаслеђа треба да буде саставни део методологије научног и стручног истраживања у оквиру геозаштите, која обухвата: истраживање и проучавање геодиверзита одређеног подручја, квалитативну евалуацију и издвајање потенцијалних објеката геонаслеђа, квантитативну процену објеката, процену постојећег стања и степена угрожености објеката, и предлоге одговарајућих заштитних мера као и активности усмерених на популаризацију, презентацију и промоцију објеката геонаслеђа. Примена квантитативне (нумеричка) процене објеката један је од начина да се субјективност процењивача сведе на најмању могућу меру.