Geologia Croatica
Journal of the Croatian Geological Survey and the Croatian Geological Society
2016 | 69/3 | 337–345 | 7 Figs. | 3 Tabs. | www.geologia-croatica

Upper Cretaceous geosites on Golija Mountain – objects of geoheritage

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doi: 10.4154/gc.2016.28

Article history:
Manuscript received March 25, 2016
Revised manuscript accepted August 16, 2016
Available online October 25, 2016

Keywords: geoheritage, geosite, geoconservation, geotourism, rudists, Upper Cretaceous, Mt. Golija, SW Serbia

Abstract

The Upper Cretaceous rudist limestones are well-known from several localities in Serbia. Three of these localities (Svilanovo, Bele Vode and Kulizino Selo) are located in SW Serbia, on Golija Mt. These localities are crucial for understanding the development of the Upper Cretaceous shallow-water environments, thus this is an area of great scientific and educational value, particularly considering palaeontology, stratigraphy, palaeoecology and palaeogeography. One of the aims of this paper is to evaluate these geosites and their geotouristic potential, using Geosite Assessment Model (GAM), which is important for their geoconservation as well as for the sustainable development of the area.

1. INTRODUCTION

The systematic study of the geological heritage and geodiversity in Serbia started relatively recently (MARAN, 2008, 2010; RUNDIĆ & KNEŽEVIĆ, 2005; MIJOVIĆ et al., 2005; KARAMATA & MIJOVIĆ 2005; STOJANOVIĆ & MIJOVIĆ, 2008; VUJIČIĆ et al., 2011; JOVANOVIĆ et al., 2012; RABRENOVIĆ et al., 2014; MARAN STEVANOVIĆ, 2015). An inventory of Serbian geoheritage sites includes approximately 650 geological, palaeontological, geomorphological, spelaeological and neotectonic sites (ĐUROVIĆ & MIJOVIĆ, 2006).

This study focuses on the Upper Cretaceous limestone with rudist fauna in the area between Sjenica and Raška (Fig. 1). Here, there are several outcrops of major importance for scientific knowledge and study of Upper Cretaceous fossiliferous sediments. However, considering their geological and palaeontological characteristics, only three of these localities (Svilanovo, Kulizino Selo and Bele Vode) seem to be interesting from the aspect of geological heritage. These localities are very important from the geological point of view, thus the aim of this paper is to present the main scientific arguments for considering these localities to be a part of Serbian geoheritage.

Remains of rudist limestones are scattered on the slopes of Mt. Golija which is the highest mountain in SW Serbia. Mt. Golija has been under state protection as the Golija Nature Park, since 2001. The Golija Nature Park was placed in category I as a natural resource of exceptional importance. Because of the exceptionally well-preserved natural environment, but also because of its cultural resources, the committee of the UNESCO's Man and the Biosphere Programme (MAB) set up the Golija-Studenica Biosphere Reserve within the Golija Nature Park. Besides their scientific significance, the beautiful landscape and cultural heritage reveal the high touristic potential of these localities, thus making them quite important from educational, touristic and cultural points of view. All the three localities are easily accessible, since they are situated along asphalt roads.

The main purpose of this paper is to evaluate different geosites using the preliminary Geosite Assessment Model (GAM) proposed by VUJIČIĆ et al. (2011) in order to determine whether this area has the potential for geotourism development.

2. GEOLOGICAL SETTING AND GEOSITES SELECTION

The region of western and southwestern Serbia is characterized by an extremely complex geological setting, as a result of collisional processes between the Adria microplate and the European plate. The area is composed of the continental Drina-Ivanjica, Jadar-Kopaonik and East-Bosnian-Durmitor Units, as well as two ophiolite belts, which are remnants of oceanic crust that are derived from the Neotethys (DIMITRIJEVIĆ & DIMITRIJEVIĆ, 1973; ROBERTSON & KARAMATA, 1994; DIMITRIJEVIĆ, 2001; KARAMATA, 2006). Recent investigations showed that the double belt appearance (Western Vardar Zone and Dinaridic Ophiolite Belt) and complicated present day geological relationships between the continental and oceanic units are the results of Late Jurassic obduction, followed by strong folding and out of sequence thrusting (PAMIĆ et al., 1998; HRVATOVIĆ & PAMIĆ, 2005; CSONTOS et al., 2003; SCHMID et al., 2008).

The Late Jurassic to Early Cretaceous transgressive phase, characterized predominantly by alluvial to neritic sedimentation, started after obduction and subsequent erosion in the Dinaridic-Hellenic belt (PAMIĆ et al., 1998; PAMIĆ & HRVATOVIĆ, 2000; SCHMID et al., 2008). In western and southwestern Serbia, however, these sediments are absent, possibly due to Early to mid-Cretaceous collisional processes (SCHMID et al., 2008). In this region, both Palaeozoic and Mesozoic sediments of the Drina-Ivanjica and Jadar-Kopaonik Units, which derived from the passive margin of Adria, and Jurassic rocks of oceanic origin that belong to the Vardar Zone, are unconformably overlain by Upper Cretaceous transgressive clastic sediments containing redeposited ophiolite fragments. Carbonate and terrigenous-carbonate sedimentation followed through the Upper Cretaceous until

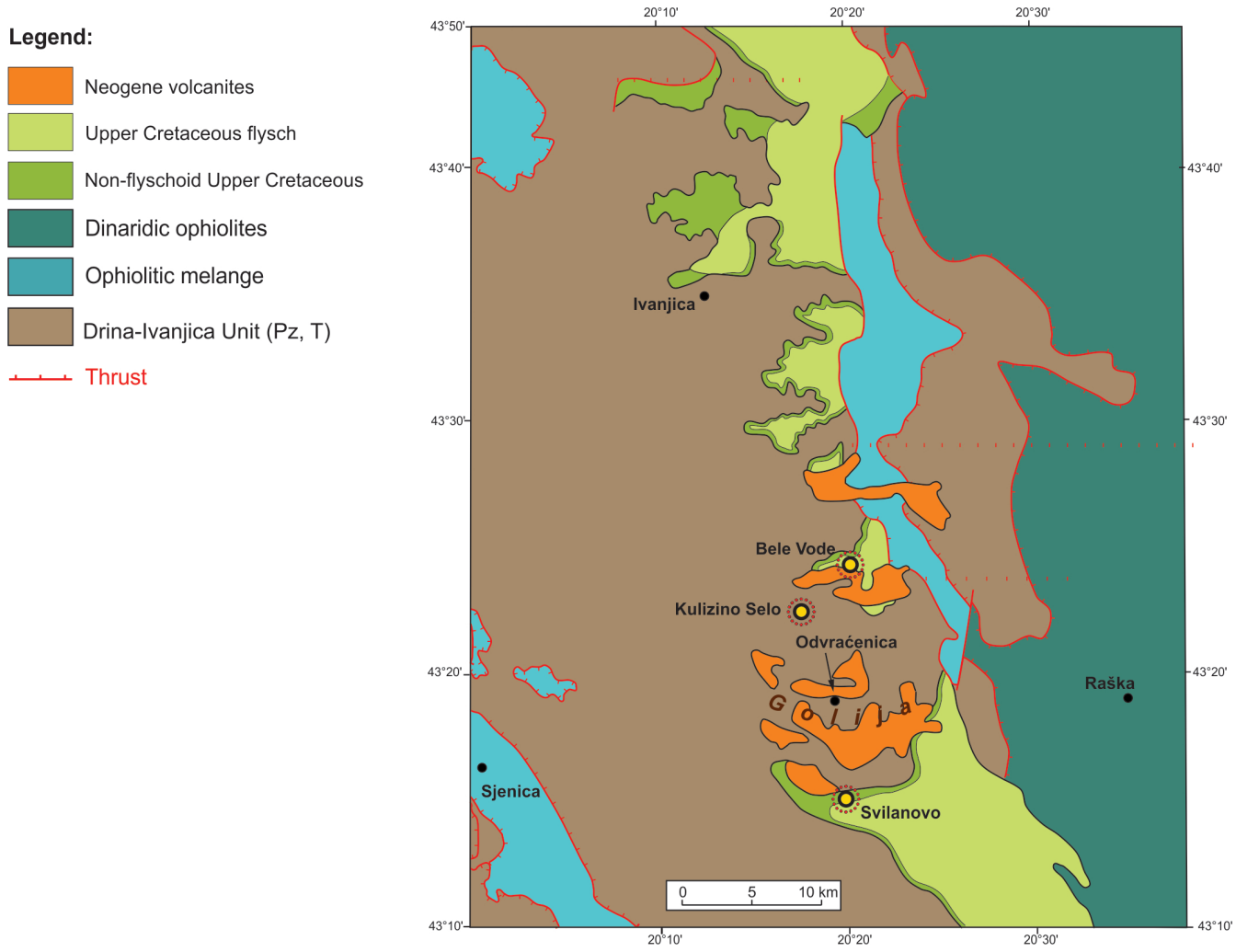

Figure 1. A simplified and modified geological map of the wider surroundings of the investigated area, based on the Geological Map of SFRY 1:500000 (SAVEZNI GEOLOŠKI ZAVOD, 1970).

the Maastrichtian when flysch sedimentation began (MOJSILOVIĆ et al., 1980; FILIPOVIĆ et al., 1978).

The wider investigated area belongs to the Cretaceous cover of Palaeozoic rocks on the eastern rim of the Drina-Ivanjica Unit, i.e. to a belt of Cretaceous sediments, known as „Novi Pazar Cretaceous„ (RAMPNOUX, 1970) that can be traced from Kosovo towards the north and northwest to the area of Dragačevo. The complete Cretaceous stratigraphic sequence can be traced only in the western part of this belt.

In this area, the Cretaceous sedimentary succession begins with a 30 m thick basal conglomerate and conglomeratic limestone succession, which is overlain by a shallow-water limestone with Santonian-Campanian fauna represented by hippuritids, radiolitids, globotruncanids, gastropods and echinoids which is about 50 m thick. Rudist limestones are generally considered as products of typical reefal sedimentation (e.g. MILOVANOVIĆ, 1960; ROSS, 1992; KOCH et al., 2002). However, there are other opinions (e.g. GILI et al., 1995; SANDERS, 1998) suggesting that Cretaceous rudists were unable to build bioherms similar to Holocene coral reefs, but were gregarious sediment-dwelling aclonal suspension feeders. Cretaceous sedimentation ends with a thick sequence of preflysch and flysch sediments of Campanian and Maastrichtian age (RAMPNOUX, 1964, PETROVIĆ & JANKIČEVIĆ, 1988), i.e. the so-called Kosovska Mitrovica flysch (DIMITRIJEVIĆ & DIMITRIJEVIĆ, 1987; DIMITRIJEVIĆ, 1997).

In the area between Čačak and Novi Pazar, outcrops of the Upper Cretaceous rudist limestone occur in the form of a narrow strip along the rim of the overlying flysch deposits. There are also several small lenslike bodies of rudist limestone on the northern slopes of Golija Mountain. With an abundance of exceptionally large and well-preserved fossils, three localities at which the Upper Cretaceous limestone are exposed, Svilanovo, Kulizino Selo and Bele Vode, should be considered as potentially important for Serbian geoheritage (Fig. 1).

Svilanovo village is located on the southern slopes of Mt. Golija, about seven kilometres from the mountain peak Odvraćenica (N 43°14'40" E 20°19'54"). Direct access to the locality is along a good asphalt road that branches from the Novi Pazar-Golija road. Lying over low-grade metamorphosed schists of Carboniferous age, Upper Cretaceous rudist limestone makes a conspicuous, more than 500 m long scarp along a relatively steep slope (Fig. 2).

The massive biomicritic limestone was deposited under shallow-water conditions. A heterogeneous fossil association comprises foraminifers, detritus of bivalves, gastropods, echinoids, corals, etc. (Fig. 3). The dominant macrofossils are rudist bivalves (Fig. 4) from the genera *Radiolites, Lapeirouseia, Pironea, Hippurites,* etc. (ĆIRIĆ, 1996).

In the nearby vicinity, another profile of Upper Cretaceous rudist limestone is exposed in the village of **Bele Vode**, on the northern slopes of Golija mountain, along the Ivanjica-Golija road

Figure 2. Scarp composed of Upper Cretaceous rudist limestone, Svilanovo village.

Figure 4. A rudist bivalve in growth position.

Figure 3. Abundant fossils in Upper Cretaceous limestone, locality Svilanovo.

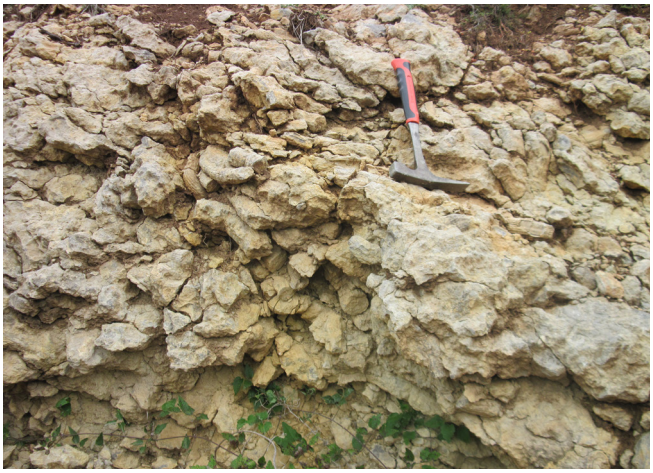

Figure 5. Limestone with rudist bivalves at the locality of Bele Vode.

(N 43°24'09" E 20°17'50"). At this locality, Upper Cretaceous sediments transgressively overlie Carboniferous schists. The Upper Cretaceous sequence starts with clastic sediments which are overlain by light gray biomicritic limestone with abundant rudists, corals and echinoids. The sedimentation regime was occasionally interrupted by the inflow of clayey-silty material, which resulted in the occurrence of several metres of bedded marly limestone. The succession ends with a massive limestone that contains rudists from the genera *Lapeirouseia, Hippurites, Radiolites, Pironea*, etc. (Fig. 5).

The third locality is situated in the village of **Kulizino Selo**, south of Bele Vode (N 43°22'55" E 20°17'32"). At this locality, Cretaceous rudist limestone lies above a relatively thin sequence composed of clastic sediments. A horizon of yellowish clayey limestone with densely packed small rudists, other bivalves and gastropods occurs within the massive limestone with large rudists (Fig. 6). Rudists at this locality mostly belong to the following genera: *Lapeirouseia, Vaccinites, Hippurites, Radiolites* and *Pironea*. The most important rudist specimen belongs to the species *Lapeirouseia crateriformis*. With a diameter of the upper valve of more than 60 cm, it is the largest rudist ever found in the Dinarides (ĆIRIĆ, 1996).

These geosites are important for understanding the evolution of the wider region of Golija Mountain, making this area of great scientific value, particularly considering palaeontology, stratigraphy, palaeoecology and palaeogeography.

Eastern and central Mediterranean Rudist species *Vaccinites atheniensis* Ktenas (younger synonym of *V. chaperi*; STEUBER, 1999), occurring at all these localities (MILOVANOVIĆ, 1975),

Figure 6. A large rudist specimen, Kulizino Selo locality.

can be used for correlation with sedimentary rocks from distant regions. According to MILOVANOVIĆ (1934), in the terrains of Serbia (vicinity of Kosovska Mitrovica, Novi Pazar, Raška, Golija) this species belongs to the same association as in the Gossau Cretaceous sediments of the Eastern Alps, thus it should have the same stratigraphic position as in the eastern Alps, i.e. Late Santonian – Early Campanian. Recent chemostratigraphic ages reported from the surrounding regions (SWINBURNE at al., 1992) indicate the Campanian age of similar rudist-bearing limestones. Besides, these sediments show strong similarities to the limestone of the Pučišća Fm. in the eastern part of Brač (vicinity of Povlja) in Croatia, which are assigned an early Campanian age (STEUBER et el., 2005). Therefore, considering the absence of micropalaeontological data from our localities and the recently revised ages of similar rudist associations in the wider region, the general age of the rudist limestone on Golija Mt. is probably Campanian (?early Campanian).

3. METHODS

There are numerous papers on the evaluation of geosites worldwide (e.g. HENRIQUES et al., 2011; TOMIĆ, 2011; VUJIČIĆ et al., 2011; MOUFTI et al., 2013; PETROVIĆ et al., 2013; VASILJEVIĆ et al., 2014; GNEZDILOVA et al., 2015; BOŠKOV et al., 2015; BEGAN & VIŠNIĆ, 2015). Different methods have been proposed for geoheritage assessment (e.g. PRALONG, 2005; PEREIRA et al., 2007; REYNARD et al., 2007; VUJIČIĆ et al., 2011; FASSOULAS et al., 2012; TOMIĆ & BOŽIĆ, 2014; MARAN STEVANOVIĆ, 2015) based on quantification of different characteristics of geosites.

In this paper, evaluation of the chosen localities is based on the preliminary geosite assessment model (GAM), created by VUJIČIĆ et al. (2011). This method involves the quantification of two groups of indicators. The first group (Main values) comprises scientific/educational (VSE), scenic/aesthetical (VSA) and protection (VPr) values. These values are crucial for geoheritage assessment. However, the other group of indicators (Additional values), which includes functional (VFn) and touristic values (VTr), is important for considering the geotouristic potential of a site. All indicators are assigned values grading from 0 to 1.

After evaluating each element in both groups of indicators, the total value was calculated for each group. The results obtained are presented in a discrimination diagram, where the Main and Additional values for each site are plotted against each other along the X and Y axes, respectively. The matrix is divided into nine fields and the position of each geosite within one of these fields shows its importance as an object of geoheritage and suggests plans of action for protection and sustainable management of the geosite.

4. RESULTS AND DISCUSSION

With the aim of evaluating the geosites on Golija Mt., three localities have been studied as potentially interesting sites of geoheritage significance. Main and Additional values for each subindicator are given in Tables 1 and 2, respectively. According to MOUFTI et al. (2013), short explanations for the assigned values are given in Tables 1 and 2. The total scores of the Main indicators were plotted against the values of the Additional indicators (Fig. 7).

The Svilanovo locality has a high value of Main (8.75) and medium value of Additional (7.75) indicators. The overall grade puts the Svilanovo locality (GS1) in the Z_{32} cell (Fig. 7). The value of the Main indicators (Table 1) is relatively high, considering the

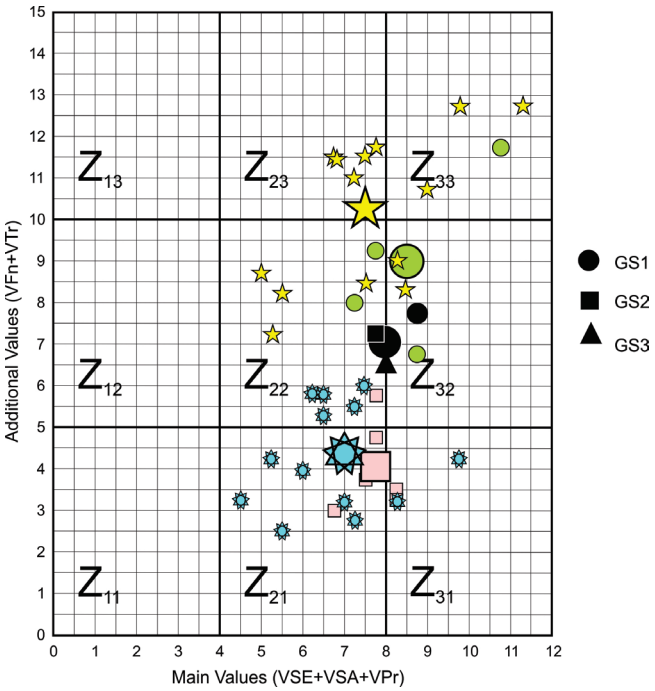

Figure 7. Location of the assessed geosites (GS 1 – Svilanovo, GS 2 – Bele Vode, GS 3 – Kulizino Selo) in GAM matrix, together with other previously evaluated geosites in the region. Legend: ☼ – geosites on Fruška Gora Mt. (VUJIČIĆ et al., 2011); ☆ – geosites on Papuk Mt. (PETROVIĆ et al., 2013); □ – geosites in Bela Crkva Municipality (BOŠKOV et al., 2015); ○ – geosites in SE Serbia (BEGAN & VIŠNIĆ, 2015). Mean values for each group of geosites is presented by large symbols.

fact that there is no formal protection whatsoever. Additional values (Table 2) are at a moderate-to-high level due to a poorly developed touristic sector (no promotion, interpretative panels or tour guide service).

The Bele Vode locality (GS2) is in the Z_{22} field (Fig. 7). The Main indicator value (7.75) for this locality is somewhat lower due to the fact that there was short-lived limestone exploitation at this locality (Table 1). Additional indicators value (7.25) is also slightly lower than in the previous locality (Table 2).

The third locality, Kulizino Selo (GS3) falls on the boundary between Z_{22} and Z_{32} (Fig. 7). The overall Main indicators value (8.00) is quite similar to that of the previous two localities (Table 1), but the final grade is lower due to the much lower values of the Additional indicators (6.50; Table 2).

Finally, we compared our results with other geological and geomorphological sites evaluated using the same method, i.e. the localities on Fruška Gora Mt. (VUJIČIĆ et al., 2011; PETROVIĆ et al., 2013) and Papuk Mt. (PETROVIĆ et al., 2013), as well as in Bela Crkva municipality (BOŠKOV et al., 2015) and other evaluated geomorphological geosites in SE Serbia (BEGAN & VIŠNIĆ, 2015) (Table 3).

It is evident from Fig. 7 that, according to the mean Main indicator values, the analyzed geosites on Golija Mt., as all other geosites in the region that were previously evaluated by GAM method, fall in the fields Z_{2y} and Z_{3y} (y=1,2,3). This indicates their scientific significance and potential for geotourism and geoconservation.

The obtained data show that the mean value for the group of indicators of Main Values for the studied geosites on Golija Mt. (8.16) is slightly higher than for most of the other evaluated sites in the region. Analysis of different subindicators of Main values shows that although VSE and VPr are balanced and relatively

Table 1. Main values (according to the GAM method proposed by VUJIČIĆ et al., 2011) of geosites of Golija Mt.

Geosites/Geotopes	Svilanovo	Bele Vode	Kulizino Selo
I Scientific/Educational values (VSE)			
1. Rarity			
Common=0			
Regional=0.25			
National=0.5	**0.5 –** Upper Cretaceous limestone with rudist fauna, rare in the Serbian part of the Dinarides, probably not so unique globally	**0.5** – Upper Cretaceous limestone with rudist fauna, rare in the Serbian part of the Dinarides, probably not so unique globally	**0.5** – Upper Cretaceous limestone with rudist fauna, rare in the Serbian part of the Dinarides, probably not so unique globally
International=0.75			
The only occurrence=1			
2. Representativeness			
None=0			
Low=0.25			
Moderate=0.5		**0.5** – fairly representative for Upper Cretaceous rudist-bearing carbonate platform environment	**0.5** – fairly representative for Upper Cretaceous rudist-bearing carbonate platform environment
High=0.75	**0.75** – representative for Upper Cretaceous rudist-bearing carbonate platform environment in western Serbia, similar outcrops are known elsewhere		
Utmost=1			
3. Knowledge on geo-scientific issues			
None=0			
Local publications=0.25			
Regional publications=0.5			
National publications=0.75	**0.75 –** locality known from national geological literature	**0.75 –** locality known from national geological literature	**0.75 –** locality known from national geological literature
International publications=1			
4. Level of interpretation			
None=0			
Moderate level of processes but hard to explain to non experts=0.25		**0.25 –** relatively good example of Upper Cretaceous reef-like bioconstructions; basic geological knowledge necessary to understand the palaeoenvironment	**0.25 –** relatively good example of Upper Cretaceous reef-like bioconstructions; basic geological knowledge necessary to understand the palaeoenvironment
Good example of processes but hard to explain to non experts=0.5	**0.5 –** perfect example of Cretaceous reef-like bioconstructions**,** but basic geological knowledge necessary to understand the palaeoenvironment		
Moderate level of processes but easy to explain to common visitor=0.75			
Good example of processes and easy to explain to common visitor=1			
II Scenic/Aesthetic values (VSA)			
1. Viewpoints (each must present a particular angle of view and be situated less than 1 km from the site)			
None=0			
One=0.25			
2 to 3=0.5	**0.5** – transgressive boundary between the Late Palaeozoic metamorphics and the Upper Cretaceous limestone; a Miocene volcanic neck with columnar jointing in the vicinity	**0.5** – Upper Cretaceous rudist limestone; Late Palaeozoic metamorphics nearby	**0.5** – Upper Cretaceous rudist limestone; Late Palaeozoic metamorphics nearby
4 to 6=0.75			
More than 6=1			
2. Surface (each considered in quantitative relation to other)			
Small=0			
SM=0.25			
Medium=0.5			
ML=0.75			
Large=1	**1**-the area is several 100s of metres in size	**1**-the area is several 100s of metres in size	**1**-the area is several 100s of metres in size
3. Surrounding landscape and nature			
Minimum = 0			
Low=0.25			
Medium-0.5			
High=0.75			**0.75** – situated in a beautiful valley. The locality is surrounded by sparsely wooded topography with meadows and pastures
Utmost=1	**1** – from the top of Golija Mt., adorable view of the Pešter Plateau (Sjeničko Polje and Novopazarsko Polje). The locality is surrounded by sparsely wooded topography with meadows and pastures	**1** – situated on a slope with beautiful view of the top of the Golija Mt and the Kopaonik Mt. The locality is surrounded by sparsely wooded topography with meadows and pastures	
4. Environmental fitting of sites			
Unfitting=0			
UN=0.25			
Neutral=0.5			
NF=0.75		**0.75** – limestone exploitation started at this locality, but it was shortlived	
Fitting=1	**1 –** perfect representation of the location		**1 –** perfect representation of the location

III Protection (VPr)			
1. Current condition			
Totally damaged (as a result of human activities)=0 Highly damaged (as a result of natural processes)=0.25 Medium damaged (with essential geomorphologic features preserved) = 0.5 Slightly damaged=0.75		**0.75** – effects of previous exploitation still visible on the site	
No damage=1	**1 –** completely preserved site		**1 –** completely preserved site
2. Protection level			
None=0 Local=0.25 Reginal=0.5 National=0.75 International=1	**0**-no formal protection	**0**-no formal protection	**0**-no formal protection
3. Vulnerability			
Irreversible (with possibility of total loss)=0 High (could be easily damaged)=0.25 Medium (could be damaged by natural processes or human activities)=0.5			
Low (could be damaged only by human activities)=0.75 None=1	**0.75** – potential collectors of rudists could damage the outcrop faces	**0.75** – potential collectors of rudists could damage the outcrop faces	**0.75** – potential collectors of rudists could damage the outcrop faces
4. Suitable number of visitors			
Zero=0 0 to 10=0.25 10 to 20=0.5 20 to 50=0.75			
More than 50=1	**1 –** the open places can hold more than 50 visitors at any one time	**1 –** the open places can hold more than 50 visitors at any one time	**1 –** the open places can hold more than 50 visitors at any one time
Total (VSE+VSA+VPr)	8.75	7.75	8.00

Table 2. Additional values (according to the GAM method proposed by VUJIČIĆ et al., 2011) of geosites of Golija Mt.

Geosites/Geotopes	Svilanovo	Bele Vode	Kulizino Selo
I Functional values (VFn)			
1. Accessibility			
Inaccessible=0 Low (on foot with special equipment and expert guide tours)=0.25 Medium (by bicycle and other means of man-powered transport)=0.5 High (by car)=0.75			**0.75 –** the site is along the road, easily accessible by car
Utmost (by bus)=1	**1 –** the site is along the road, easily accessible by bus	**1 –** the site is along the road, easily accessible by bus	
2. Additional natural values			
None=0 One=0.25	**0.25** – a site of pyramidal fir (*Abies alba var. pyramidalis*)		
2 to 3=0.5		**0.5** – a site of pyramidal fir (*Abies alba var. pyramidalis*); a lot of springs in the vicinity	**0.5** – a site of pyramidal fir (*Abies alba var. pyramidalis*); a lot of springs in the vicinity
4 to 6=0.75 More than 6=1			
3. Additional anthropogenic values			
None=0 One=0.25 2 to 3=0.5 4 to 6=0.75			**0.75** – plantations of raspberries; Orthodox Medieval monasteries of Studenica, Gradac, Đurđevi Stupovi and Sopoćani; Saint Apostles Peter and Paul Church, the oldest in the Balkans.
More than 6=1	**1** – seasonal mountain settlements („katuni„); plantations of raspberries; Orthodox Medieval monasteries of Studenica, Gradac, Đurđevi Stupovi and Sopoćani; Saint Apostles Peter and Paul Church, the oldest in the Balkans.	**1** – several sculpture fountains; plantations of raspberries; Orthodox Medieval monasteries of Studenica, Gradac, Đurđevi Stupovi and Sopoćani; Saint Apostles Peter and Paul Church, the oldest in the Balkans.	

4. Vicinity of emissive centres			
More than 100 km=0 100 to 50 km=0.25 50 to 25 km=0.5		**0.5** – 30km from Ivanjica	**0.5** – 35km from Ivanjica
25 to 5 km=0.75 Less than 5 km=1	**0.75** – 20km from Novi Pazar		
5. Vicinity of important road network			
None=0 Local=0.25	**0.25** – the asphalt road Novi Pazar-Golija	**0.25** – the local asphalt road	**0.25** the local asphalt road
Regional=0.5 National=0.75 International=1			
6. Additional functional values			
None=0 Low=0.25 Medium=0.5 High=0.75 Utmost=1	**1 –** along the asphalt road to Novi Pazar-Golija and Sjenica-Golija	**1 –** along the asphalt road to the village of Bele Vode	**1 –** along the asphalt road to the village of Kulizino Selo
II Touristic values (VTr)			
1. Promotion			
None=0 Local=0.25 Regional=0.5 National=0.75 International=1	0	0	0
2. Annual number of organized visits			
None =0 Less than 12 per year=0.25 12 to 24 per year=0.5 24 to 48 per year=0.75 More than 48 per year=1	**0.25** – geologists, geology students	**0.25** – geologists, geology students	**0.25** – geologists, geology students
3. Vicinity of visitors centre			
More than 50 km=0 50 to 20 km=0.25 20 to 5 km=0.5		**0.5** – rural tourism	**0.5** – rural tourism
5 to 1 km=0.75 Less than 1 km=1	**0.75** – In the Golija Nature Park		
4. Interpretative panels (characteristics of text and graphics, material quality, size, fitting to surroundings, etc.)			
None=0 Low quality=0.25 Medium quality=0.5 High quality=0.75 Utmost quality=1	0	0	0
5. Annual number of visitors			
None =0 Low (less than 5000)=0.25 Medium (5001 to 10.000)=0.5 High (10.001 to 100.000)=0.75 Utmost (more than 100.000)=1	0.25	0.25	0.25
6. Tourism infrastructure (pedestrian pathways, resting places, garbage cans, toilets, wellsprings etc.)			
None=0 Low=0.25 Medium=0.5	**0.5** – pedestrian paths in the vicinity, wellsprings	**0.5** – pedestrian paths in the vicinity, wellsprings	**0.5** – pedestrian paths in the vicinity, wellsprings
High=0.75 Utmost=1			
7. Tour guide service (expertise level, knowledge of foreign language(s), interpretative skills, etc)			
None=0 Low=0.25 Medium=0.5 High=0.75 Utmost=1	0	0	0
8. Hostelry service			
More than 50 km=0 25-50 km=0.25 10-25 km = 0.5 5-10 km=0.75		**0.5** – On Golija Mt	**0.5** – On Golija Mt
Less than 5 km=1	**1** – On Golija Mt		
9. Restaurant service			
More than 25 km=0 10-25 km=0.25 10-5 km=0.5 5-1 km=0.75	**0.75** – On Golija Mt		**0.75** – Village tavern nearby
Less than 1 km=1		**1** – Village tavern nearby	
Total (VFn + VTr)	7.75	7.25	6.50

Table 3. Mean Main and Additional values for different geosites in Serbia, according to the GAM method proposed by VUJIČIĆ et al., 2011.

Geosites	Papuk Mt. (according to PETROVIĆ et al., 2013)	Fruška Gora Mt. (according to VUJIČIĆ et al., 2011)	Bela Crkva municipality (according to BOŠKOV et al., 2015)	SE Serbia (according to BEGAN & VIŠNIĆ, 2015)	Golija Mt. (this publication)
Mean Main Values	7.57	7.02	7.70	8.55	8.15
VSE	2.43	2.46	2.00	3.30	2.16
VSA	2.71	2.43	2.83	2.56	3.33
VPr	2.43	2.13	2.87	2.69	2.66
Mean Additional Values	10.25	4.29	4.00	8.90	7.16
VFn	3.61	2.94	2.37	4.50	4.08
Vtr	6.64	1.35	1.63	4.40	3.08

high, the differences in Main values mostly depend on VSA. The highest VSA for the studied geosites on Golija Mt. (3.33) are due to the large surface areas of the outcrops, the beautiful landscape and their untouched nature. Most of the subindicators representing Protection (VPr) are very high for geosites on Golija Mt., but they are significantly lowered due to the lack of any kind of formal protection. Although VSE for sites on Golija Mt. are quite satisfactory (2.16), low values of Level of interpretation show that these geosites might be interesting in the first instance for people with a geoscience background.

The calculated mean Additional values of different groups of geosites greatly differ (from Z_{x1} to Z_{x3}, x=1,2,3), depending on the overall development of an area, the number of potential visitors, touristic infrastructure, management and planning, vicinity of emissive centres, etc. Mean values for the group of indicators of Additional Values for the studied localities are much lower than for geosites on Papuk Mt. and in SE Serbia, but much higher than for those on Fruška Gora Mt. and in Bela Crkva municipality. Despite rather similar Functional values (VFn) to geosites is SE Serbia and generally higher than those on Papuk Mt., geosites on Golija Mt. have much lower Touristic values (VTr). The main reason for this is insufficient development of tourism in this area. Such low VTr obtained for the studied geosites are compensated for by relatively high VFn, which results in generally high Additional Values.

5. CONCLUSIONS

The obtained results show that the Main indicators values of the analyzed geosites are high and that these localities are important from a scientific and educational point of view, which leads to the conclusion that Golija Mountain has sufficient levels of natural resources for geotourism development.

The Additional indicators values are at a medium level in all three geosites. This is not surprising, considering the fact that this is a problem for many potential sites of geoheritage significance in Serbia, because of the lack of organized visits, tour guide service, interpretative panels, etc. This implies that there is an urgent need for more rapid, though sustainable, development of the tourism infrastructure.

In order to maintain the original characteristics of these geosites, it would be necessary to protect them from negative influences that might result in degradation or complete devastation. The final aim is geoconservation of the geosites in their original, undisturbed condition, in order to preserve it for future generations. The most effective way of protection of objects of geoheritage significance is to raise the awareness of their scientific, educational, aesthetic and touristic importance, as well as to forbid their commercial exploitation. This paper shows that all the studied localities fully deserve such treatment.

ACKNOWLEDGMENT

The work was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia (Project No. 176015). We also thank the editor and two anonymous reviewers for their constructive comments, which helped us to improve the manuscript.

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