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GLOBAL GEOPARK AND CANDIDATE – COMPARATIVE ANALYSIS OF PAPUK MOUNTAIN GEOPARK (CROATIA) AND FRUŠKA GORA MOUNTAIN (SERBIA) BY USING *GAM* MODEL

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Abstract: We examined the comparison of geoheritage resources of two natural protected areas: National park Fruška Gora in Serbia and Nature Park Papuk in Croatia. The first one has applied for UNESCO geopark recognition in 2007, while the second one was proclaimed as one the same year. The general hypothesis is that these two geologically similar areas possess comparable geo-resources, which should clarify the causes because of which Fruška Gora still has not been included in geopark network. For their comparison, authors applied previously created Geosite Assessment Model (GAM). GAM consists of two key indicators: Main and Additional Values, which are further divided into 12 and 15 indicators respectively, each individually marked from 0 to 1. This division is made due to two general kinds of values: Main - that are mostly generated by geosite's natural characteristics; and Additional - that are mostly human-induced and generated by modifications for its use by visitors. The study revealed that the Main Values are similar to both, Fruška Gora and Papuk. However, Papuk Mountain, as a well developed global geopark, has higher Additional Values, with significant international recognition. As these two investigated areas are less than 200 km away from each other, one of the development options could be collaboration of these complementary geotourism destinations through an international and mutual offer that could initiate new geo-destinations and further improve and develop conservation and promotion of geoheritage in a much wider region.

Key words: geopark, geoheritage, geotourism, Papuk Mt., Fruška Gora Mt., GAM Model

1. INTRODUCTION

Recent global leisure trends, as an element of sustainable tourism, have shown heightened appreciation of non-living natural resources, or geodiversity. This variety of natural resources is defined by Gray (2004) as "the range of soil, geomorphological and geological features". The components of geodiversity that have scientific, educational, aesthetical and inspirational significance are considered to be determined as geoheritage (Dixon, 1995), and many researchers emphasize conservation significance of geoheritage (Gray, 2004; Giurginca, 2010). From the 1990s, many theorists originated the concept of "geotourism" which is generally defined and redefined by Hose (1995; 2000; 2008; 2011; 2012; Hose & Vasiljević, 2012) as "the provision of interpretative and service facilities for geosites and geomorphosites and their encompassing topography, together with their associated in situ and ex situ artefacts, to constituency-build for their conservation by generating appreciation, learning and research by and for current and future generations" (Hose, 2012). The recent geotourism concept indicates the necessity to select and inventory geosites, with support of various geological and geomorphological researches (Condorachi, 2011; Ladányi et al., 2011). This approach is very much in the vain of sustainable tourism. This can subsume ecotourism, a tourism management approach that the World Tourism Organization (1997) suggests maintains cultural integrity whilst permitting economic, social and aesthetic needs to be fulfilled; furthermore, the underpinning ecological processes and biodiversity are protected. It seeks to meet the needs of both host and tourist present and future generations through ensuring the protection and enhancement of tourism destinations.

Similar to geotourism, ecotourism has developed over the past 20 years from an obscure niche trend to a potentially dominant one in some tourism destinations (Weaver & Lawton, 2007). It only appeared for the first time in the academic literature in the late 1980s, whist geotourism appeared a decade later (Hose, 1996; 1997).

In recent years, many European countries have initiated schemes for recognising and designating important Earth's heritage (that is, geoheritage) sites within their national areas, often under the auspices of the ProGEO GEOSITES project and with IUGS support (Wimbledon et al., 2000). Such geomorphological and geological sites, when appropriately interpreted and presented, are important for educating the general public on environmental matters. They are also vehicles for generating sustainable development, through the implementation of the geopark concept, by creating areas of promoted if not necessarily statutorily protected geoheritage interest. The UNESCO promoted initial criteria (Patzak, 2000), based upon geotourism and its associated geoconservation principles previously established in the United Kingdom (Hose, 1996; 1997), for establishing geopark, which has become a powerful tool for closer understanding of the geoheritage and better exploration of the earth resources by informing the broad public to a balanced relationship between the physical environment and people. Indeed, within the geoparks movement it has been noted that "rather than exploit this heritage in the non-renewable fashion of the past, there is an opportunity to manage it in a way that conserves it for the future through the development of geotourism" (McKeever, 2009).

As this concept evolved, geoparks are defined as a: "... nationally protected area containing a number of geological heritage sites of particular importance, rarity and aesthetic appeal which can be developed as part of an integrated concept of conservation, education and local economic development" (UNESCO, 2006). In this regard, before planning and managerial actions, it is necessary to make an adequate assessment of specific geosite values in order to adequately protect, develop and present geoheritage to the general public (Pereira et al., 2007; Vujičić et al., 2011). A European Geopark is: "… *a territory which combines the protection and promotion of geological heritage with sustainable local development*" (Zouros, 2003), and each has a formal agreement with its local and regional government authorities (and with some European Union financial support) on promotion and management strategies. Each must participate in their territory's economic development by working with local small- and medium-sized enterprises on new tourism products and services. Their geological interest ideally should be allied to some archaeological, historical, cultural or ecological interest. To meet geoconservation requirements, the sale of geological material, whether local or imported, is banned within them.

In this paper we highlight and compare the geoheritage resources of two natural protected areas: National park Fruška Gora in Vojvodina Province, Serbia and Nature Park Papuk in Slavonia region, Croatia (Fig. 1). Former has applied for UNESCO geopark recognition in 2007, while latter was proclaimed as one the same year. The general hypothesis is that these two geologically similar areas possess comparable geo-resources, which should clarify the causes because of which Fruška Gora still has not been included in geopark network. For their comparison authors utilised previously created Geosite Assessment Model (in further text GAM) by Vujičić et al., (2011), which should demonstrate differences between these two areas at all relevant levels (from natural to touristic).

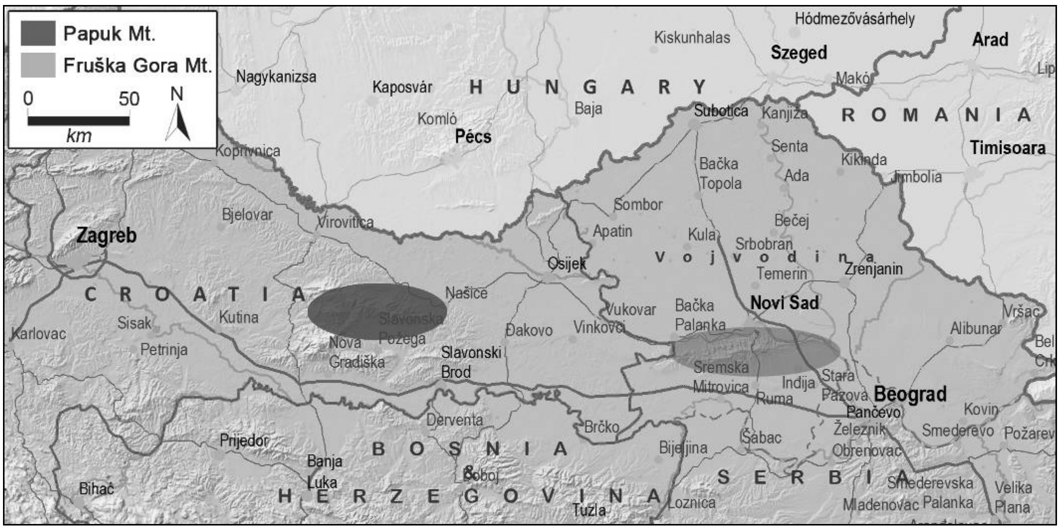

Figure 1. The position of two protected areas included in the study

2. GEOGRAPHICAL SETTINGS, OVERVIEW AND INVENTORY

2.1. National Park Fruška Gora Mountain

Fruška Gora Mountain is situated in northern Serbia, between 45° 06' and 45° 12' north latitude and 19° 12' and 20° 01' east longitude. The area is located at the right bank of Danube River, in north part of Srem District in Vojvodina region. The highest peak of the mountain is Crveni Čot (539 m), the third highest peak in Vojvodina region, after Gudurica (641 m) and Fox Head (590 m) at Vršac Mountains.

The mountain represents a dominant geomorphologic complex in this part of country, but it is also one of the most diverse geological and pedological areas in the Pannonian Plain. In Fruška Gora's core there are Palaeozoic (more than 300 million years old) and Mesozoic sedimentary rocks (from the time of the dinosaurs, from 270 million years ago until 65 million years ago), Mesozoic and Tertiary volcanic rocks and a variety of Metamorphites. At peripheral parts of the mountain, on its slopes and foothills, can be found the Neogene sediments (from the former Pannonian Sea) and the various genetic types of Quaternary formations (sediments formed during the Ice Age) (Petković et al., 1976).

Figure 2. The landscape of the Fruška gora Mountain (Photo: Lazar Lazić)

Fruška Gora Mountain was the first Serbian National Park (Fig. 2), established in 1960, with vast forest areas (over 90%) and about 5,000 ha of meadow habitats. The park has more than 1500 plant species (including the greatest concentration of linden trees in Europe) and over a 300 animal species (Butorac, 2007; Habijan-Mikeš, 2007). Beside natural values, there are 16 Orthodox Church monasteries, dating from the XVth to the XVIIIth century, monumental fortifications, together with and many castles and palaces in the surrounding areas; all of which contribute to the comprehensive value of the area.

For the purpose of this paper we used the inventory of Fruška Gora geosites determined by Marković et al., (2001) and also assessed by Vujičić et al., (2011). As shown in table 1, 14 geosites with the most distinctive aesthetic, scientific and educational values were selected for this evaluation and comparison. *Ex situ* localities were excluded from the evaluation as they cannot be assessed by this model.

Some of the proposed geosites are within the National Park and thus officially under national concern. In the protected area under regime level I are the: Paleontological site "Grgeteg" (a part of the site is under regime level II); Upper Cretaceous paleontological site in the watersheds of Orlovački, Dobri and Čerevićki streams; Paleontological site "Papradine"; Grgurevačka cave on Popov Čot (a part of the site is under regime level II) and the stone block "Orlovac". In the protected area under regime level II are: Paleontological site "Šakotinac"; Paleontological site "Krečanske jame"; Petrologic locality "Kozje brdo" and the volcanic tuff near the village of Rakovac (so called "Galerija") (Marković et al., 2001; Marković, 2007; Vujičić et al., 2011).

During 2006 to 2007 initial actions were undertaken to facilitate Fruška Gora joining the Global Geoparks Network. As a result of these actions a project entitled: "Researching geoheritage of Fruška Gora for its protection and valorisation for future Geopark", was initiated; the required research was undertaken by experts of the Geological Institute of Serbia. Their study identified across the area's terrain the terrain of numerous fossils sites and many river sections exposing geological formations. For the purpose of popularising of conservation, importance and value of geological heritage objects for scientific research, the planned activities are related to their arrangement in which one must take into account that the main goal is to preserve existing natural features that make these sites placed under protection.

2.2. Geopark Papuk Mountain

Papuk Mountain is the greatest integral part the Slavonian Mountains, situated in northern Croatia, between 45°22' and 45°38' north latitude, and 17°27' and 17°55' east longitude. The highest summit of the mountain is Papuk peak at 953 m (the second highest peak in Slavonia region, after Brezovo polje peak at 984m). Scientific research of the Papuk Mountain and all other Slavonian Mountains started in the middle decades of 20th century. The first paper on the genesis of the granitoid was by Tajder (1957). In the next decade, Raffaelli (1965) wrote about a progressive metamorphic rock series at the southern slope of Papuk Mountain, and several authors (Pamić, 1988; Pamić & Lanphere 1991, Pamić, et al., 1996) dealt with the petrography of granitoid and metamorphic rocks of the central and western part of Papuk Mountain. Biotite in granitoids was investigated by Slovenec (1978).

Table 1. Preliminary list of geosites of Fruška Gora Mountain - $GSFG_{1-14}$ (Marković et al., 2001)

No.	Geosite Name and Label	Description
1	The site of volcanic tuff "Galerija" near Rakovac village - $GSFG_1$	Tuff horizon (8 m thick) interstratified between Miocene - Tortonian layers. The monument of Nature since 1982 (Knežević, 1998).
2	Trachyte Quarry "Kišnjeva glava" - $GSFG_2$	Trachyte dyke injected into Cretaceous formations of sandstone and flysch. The hight of steep slopes up to 80 m (Petković et al., 1976).
3	Trachyte Quarry "Srebro" near Ledinci village – $GSFG_3$	Abandoned quarry with lake of exceptional aesthetic values. Steep slopes high up to 110 m. Very good display of geo- and biodiversity (Petković et al., 1976).
4	Palaeontological site of Miocene marine fossils- "Filijala" near Beočin village - $GSFG_4$	Upper Miocen-Pannonian sediments with rich presence of caspibrackish water fauna. This site is considered as important checkpoint for sediment age determination in the region of ancient Tethys Ocean as a parastratotype (Knežević, 1998).
5	Palaeontological site of Cretaceous marine fossils in Čerević village – $GSFG_5$	The most complete succession of the Upper- Cretaceous sediments. Fossil remains of *Orbitoides*, *Loftusias*, corrals, worms, *Brachiopods*, *Gastropods* and *Lamelibranhiats* (Petković et al., 1976).
6	Palaeontological locality of the mio-pliocenic fossils-"Grgeteg" – $GSFG_6$	The sediments of Sarmat, Upper Pontian and Pannonian age with rich caspibrachish water mollusk fauna. More than 40 species were extracted and determined from the exposed site (Knežević, 1998; Petković et al., 1976).
7	The structural palaeontological site of Neogene gastropod marine fossils near Stari Slankamen village – $GSFG_7$	Pannonian age sediments in discordant and transgressive position overlaying Badenian age limestones with numerous fossil marine gastropods (Knežević, 1998).
8	"Grgurevačka" cave – $GSFG_8$	A unique karst underground geomorphological object in Vojvodina, northern Serbia (Petrović, 1966)
9	A gorge-like part of Almaš brook valley – $GSFG_9$	Composite valley in the lower course of brook (of around 100 m) sediments with small waterfalls formed in loess sediments (Miljković et al., 1998)
10	Vrdnik mine - $GSFG_{10}$	Abandoned coal mine with rich geological depository revealed in 26 underground mine shafts up to 280 m of depth (Vasiljević & Marković, 1999).
11	Loess section - "Ruma" brickyard - $GSFG_{11}$	Detailed evidence of paleogeographic events during the last 450 000 years. Fossil remains of the large Pleistocene mammals: *Mamuthus primigenius* and *Ursus deningeri* (Marković et al., 2004; 2006).
12	Loess profile "Surduk" in the gully between Novi and Stari Slankamen villages - $GSFG_{12}$	Currently the only law protected loess exposure in Serbia with fossil palaeosols (Vasiljević, 2011a; 2001b).
13	Loess section in "Irig" - $GSFG_{13}$	The most northern profile with temperate and arid like terrestrial fossil malacofauna which indicates the existence of dry and warm glacial palaeoclimate (Marković et al. 2007)
14	Loess profile "Čot" in Stari Slankamen village - $GSFG_{14}$	40 m tick section with 10 palaeosols (contains valuable paleoclimatic and paleoenvironmental records of the Middle and Late Pleistocene) (Schmidt, 2010; Marković, 2011).

Figure 3. Geosite Rupnica at Papuk Mountain Geopark (Photo: Dinko Pešić)

The Papuk Mountain is characterized by biotite-gneisses and migmatites with amphibolite and amphibole-schist intercalations, further on granitoids (pegmatites), chlorite-schists and serpentinites with relics of peridotite (Pamić et al., 2003). This Complex is thought to have been formed during the Caledonian orogeny and was intruded by late-Variscan granitoids (Jamičić & Brkić 1987; Jamičić, 2003). Sedimentation began again in the Uppermost Permian and continued in the Triassic, Jurassic and the lowermost part of the Cretaceous. Based on K-Ar and Rb-Sr isotopic data most of the metamorphic and igneous rocks from Papuk Mountain were formed during the Variscan orogeny (340–320 Ma) although, some data indicate older ages (658–421 Ma) (Pamić, 1988; Pamić et al., 1988; 1996; Pamić & Lanphere, 1991). Pamić et al., (1998) claimed that seven pre-Alpine terrains were distinguished between the Adriatic Sea and the Pannonian Basin.

Besides the geochronological, we can find lithographical diversity represented in variety of rocks made during sedimentary, metamorphic and magmatic processes. The most certain proof about time of formation of rocks are obtained by the radiometric method of determining ages, and the majority of results in the oldest complexes, are between 352 and 376 million of years (upper Devonian to Carboniferous). Several results direct to the Precambrian age (421-650 million years), and are explained as the remaining of the basement rocks, which were base for the complexes of rocks of the Paleozoic age (Kovács Kis et al., 2004). Korolija & Jamičić (1989) made a detailed petrographic description of the granitoids and pegmatites of Papuk. Few years later, Pamić & Lanphere (1991) and Pamić, et al., (1996) gave the geodynamical model for the pre-alpine evaluation of geological processes based on geochemical and isotope data. The represented geological formations were created in the several orogeny cycles during the geological history (Baikalian, Caledonian, Hercynian or Alpine), while in the final formation, the neo-tectonic movements had the main role (Jamičić, 2003). The most important geological processes of creation are connected with the area of Hercynian orogeny (Late Paleozoic time), and are represented with: progressively metamorphic complex, I-type granite and contact metamorphic rocks, migmatites, and S-type granites, as well as semi-metamorphic complex (Pamić et al., 1996).

The geologically youngest creations are connected to the Alpine orogeny, which could be found in the Mesozoic sediments, which are between 65 and 260 million years old (Permo-Triassic, Triassic, and Cretaceous). The end of Mesozoic time is represented in the Cretaceous volcanic-sedimentary complex. In the brim of Papuk Mountain there are the Neogene sediments of the Pannonian basin. All of the mentioned creations were found hundreds of kilometres further in the area of the Drava River. The complexity of geological conditions also stipulated an interest in hydro geological phenomenon, such as natural thermal springs in the valley of stream *Dubočanka* (Pamić et al., 1998; Pamić et al., 2003).

For the purpose of this research, we used the inventory of geosites at Papuk Mountain, indentifying 14 *in situ* geosites (Table 2). We endeavour to choose the geosites according to similar values which we used on the example of Fruška Gora. *Ex situ* sites were excluded from this paper because their characteristics could not be assessed by the selected indicators and thus could not be evaluated properly by GAM. In 2007, Papuk Mt. has been awarded with a Geopark status and became a member of the Global and European Geopark Network under protection of UNESCO (Balen, 2011).

3. METHODOLOGY

The methodology of this study is based upon the 'geosite assessment model' (GAM) created by Vujičić et al., (2011). This model was assisted by a number of relevant papers (e.g. Hose, 1997; Bruschi & Cendrero, 2005; Coratza & Giusti, 2005; Pralong, 2005; Pereira, et al., 2007; Serrano & González-Trueba, 2005; Zouros 2007; Reynard, et al., 2007; Reynard 2008) that also dealt with the evaluation of geosites. GAM consists of two key indicators: Main Values (Table 3) and Additional Values (Table 4), which are further divided into 12 and 15 indicators respectively, each individually marked from 0 to 1. This division is made due to two general kinds of values: main - that are mostly generated by geosite's natural characteristics; and additional - that are mostly human-induced and generated by modifications for its use by visitors.

The **Main Values** comprise three groups of indicators: scientific/educational, scenic/aesthetical values and protection, which are more detailed presented in table 3.

The first group assesses scientific/educational values through rarity, which indicates its uniqueness on various levels (from common to only one) and representativeness that was determined by Pereira et al., (2007) as didactic and exemplary characteristics of the site due to its own quality and general configuration. This group of indicators also includes knowledge on geo-scientific issues and level of interpretation were the former evaluates the number of written papers in acknowledged journals, thesis, presentations and other publications of a geosite and later ranks the level of interpretive possibilities on geological and geomorphologic processes, phenomena and shapes, and level of scientific knowledge (Table 3).

The second group of indicators should provide the condition and physical aspect of geosites, such as the number of viewpoints accessible by a pedestrian pathway, surface of the site, surrounding landscape and nature (with emphasis on panoramic view quality, presence of water and vegetation, absence of human-induced deterioration, vicinity of urban areas, etc.) and environmental fitting of sites (level of contrast to the nature, contrast of colors, appearance of shapes, etc.). The indicator group regarding protection considers its level, actual state of geosite, vulnerability and proposed number of visitors on the site, which is determined according to previous three indicators.

Table 2. Preliminary list of geosites of Papuk Mountain ($GSPA_{1-14}$)

No.	Geosite Name and Label	Description
1	The site of volcanic rocks "Rupnica" (Figure 3), near Voćin village –GS_{1A}	Part of the petrologically heterogeneous volcanic rock formation composed of various types of basalt, andesite and tuff. According to the opinion of one group of geologists, this geological formation was created 70 million years ago (during Cretaceous geologic period), but another group of geologists supports the idea that this volcanic body is created during the evolution of the Pannonian basin (during Miocene geological epoch). This is the first proclaimed geological monument of nature in Croatia from 1948.
2	Geological profile "Jankovac" – GS_{2A}	Represents continuous geological display of transitional horizons from Permo-Triassic to the Lower Triassic geological period. Permo-Triassic depositions are presented with quartz sandstones, while other sandstone and sill formations correspond with the Lower Triassic period. Sediment layers are fossil-rich and its age corresponds to the Lower Triassic geological period.
3	The rock formation "Trešnjevica", near Novo Zvečevo village – GS_{3A}	Represents outstanding geological site that is very suitable for educational purposes. The site is composed of variety of igneous and metamorphic rocks. Also, there is a number of volcanic sills and dikes which penetrates the older crystalline complex. Geological peculiarity of this geosite lies in its rich geodiversity which is represented by rhyolite, andesite, basalt, tuff, granite, pegmatite, gneiss and magmatite formations. Excellent display of geo and biodiversity.
4	Mala Rijeka valley, near road Kutjevo-Orahovica village – GS_{4A}	Metapelite rock complex with high schistosity, intensively folded.
5	Vetovo quarry, eroded schists formation combined with amphibolite – GS_{5A}	Amphibolite and amphibole schists incorporated into metamorphosed gneiss formation. Alongside metamorphosed gneiss formation there are also metamorphosed granite and pegmatite intrusions.
6	Stratigrafic profile "Slatinski Drenovac" – GS_{6A}	This geosite is located in the riverbed of the Kovačica stream with exposed sediments from Sarmat geological period. This geological *in- situ* display is consisted of marlstone, sandstone and marly limestone formations with high concentration of natural bitumen deposits which are characteristic for the northern slopes of the Papuk mountain.
7	Kutjevo quarry – GS_{7A}	Paragneiss, amphibole and amphibole schist geological formations with inter-stratified and retrograde altered granitoide intrusions (granodiorite and plagiogranite).
8	Žervanjski stream, near Orahovica village – GS_{8A}	This locality reflects the basic characteristics of the “radovlac” metamorphic geological complex. Variety of the dull-collared greywacke sandstones is displayed at the site.
9	Stone formation "Potočan", near Novo Zvecevo village – GS_{9A}	This locality represents offspring of granite mass discordantly intruded by igneous rock formations of the Papuk mountain. These rocks are mostly fine to medium grained with dominant minerals such as quartz, albite, feldspar and biotite.
10	The site of "Studenački put", near Sekulinci village – GS_{10A}	This geosite is composed of the Upper Pontian sediments. This geological display is represented by homogenous and well sorted sandstones with admixture of silt and clay horizons.
11	Dolomites Quarry "Prijevor", near Orahovica village – GS_{11A}	“Prijevor” geosite is mostly consisted of dolomite formations deposited during the Lower Triassic geological period. Also, dolomite formations of the Middle Triassic age are present at this locality. These formations are presented with crystalline marlstone, dolomitic marlstone and marly-dolomitic breccia.
12	The site Orahovac lake – GS_{12A}	Lower Pontian age phosilipherous marlstone formations with fossil gastropod remains of the *Paradacna abichi, Congeria digitifera* and *Valencienius reussi*.
13	Antina cave, near Duzluk village – GS_{13A}	A unique karst underground geomorphological object in Croatia.
14	Petrov peak, near Kutjevo village – GS_{14A}	Sediments of Lower Triassic geological period with high schistosity, intensively folded due to tectonic activity. Thickness of the horizons is up to 2 dm. Sandstone horizons contain fossil gastropods such as:*Myophoria laevigata* and *Anodontophora (Myacites)*.

The **Additional Values** are divided into two groups of indicators, functional and touristic values (Table 4). Functional values (VFn) of a geosite could indirectly develop tourism as they reflect accessibility, additional natural values, additional anthropogenic values, vicinity of emissive centres, vicinity of important road network, and additional functional values. Except accessibility, which assesses easiness and possibilities of approaching to the site, all other indicators determine the level of and enhance and facilitate the visits. The rest of the functional values include the number of additional natural and cultural heritage elements (within a radius of 5 km), closeness to emissive centres and important road networks (radius of 20 km), existence of parking lots, gas stations, mechanics, etc.

Touristic values (VTr) show the level of touristic affirmation and the present condition of (geo) tourism services and facilities. It consists of nine indicators that encompass marketing and visiting service (level of promotional activities, annual number of visitors and organised visits, guide service quality), and tourism infrastructure (visitors centre, interpretative panels, accommodation, restaurants, etc.).

4. RESULTS AND DISCUSSION

All inventoried geosites, from both destinations were assessed by this methodology and the results were obtained by summarising the grades of all indicators: GAM = Main Values (VSE+VSA+VPr) + Additional Values (VFn+VTr). Geosites from Papuk Mountain were ranked by this study (Table 5) while evaluation of Fruška Gora geosites has already been completed by Vujičić et al., (2011) as shown in table 6. Both tables (5 and 6) present the sum of the Main and Additional Values for each geosite, with their mean values at the end of the columns. According to these values it is evident that mean values for the group of indicators of Main Values are slightly in advance for Papuk Mountain (7.57) by comparison with Fruška Gora (7.02).

These data indicate that our observed protected areas have similar values, i.e. their scientific, educational, scenic and aesthetic values, such as level of protection, are relatively on the same level for both. This detail shows that Fruška Gora, as a potential candidate for the geopark, possesses sufficient valid qualities and amenities to be included in the European and Global Network of National Geoparks.

Table 3. The Main Values of the GAM Model (according to Vujičić et al., 2011)

Main Indicators / Subindicators	**Grades (0-1)**				
Grade	0	0.25	0.5	0.75	1
I Scientific/Educational values (VSE)					
1. Rarity	Common	Regional	National	International	The only occurrence
2. Representativeness	None	Low	Moderate	High	Utmost
3. Knowledge on geo-scientific issues	None	Local publications	Regional publications	National publications	International publications
4. Level of interpretation	None	Moderate level of processes but hard to explain to non experts),	Good example of processes but hard to explain to non experts	Moderate level of processes but easy to explain to common visitor	Good example of processes and easy to explain to common visitor
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	1	2 to 3	4 to 6	More than 6
2. Surface (each considered in quantitative relation to other)	Small	-	Medium	-	Large
3. Surrounding landscape and nature	-	Low	Medium	High	Utmost
4. Environmental fitting of sites	Unfitting	-	Neutral	-	Fitting
III Protection (VPr)					
1. Current condition	Totally damaged (as a result of human activities)	Highly damaged (as a result of natural processes)	Medium damaged (with essential geomorphologic features preserved)	Slightly damaged	No damage
2. Protection level	None	Local	Regional	National	International
3. Vulnerability	Irreversible (with possibility of total loss)	High (could be easily damaged)	Medium (could be damaged by natural processes or human activities)	Low (could be damaged only by human activities)	None
4. Suitable number of visitors	*0*	0 to 10	10 to 20	20 to 50	More than 50

Additionally, many recent investigations have proved that more thorough research of Fruška Gora's geodiversity could bring new geosites, as was the case with loess sections (e.g. $GSFG_{11}$, $GSFG_{12}$, $GSFG_{13}$ and $GSFG_{14}$), which could further enhance its Main Values and enrich geotourism resources (Vasiljević et al., 2011a; 2011b). In this case, the Main Values could be observed as 'pre-values', which represent the basic prerequisites for any natural destination, which are taken into account for the geopark application.

Therefore, these values are comparatively consistent with the natural (non-human) disposition of area, so it is enough to invest much less effort and financial funds, which is quite opposite to Additional Values. Vujičić et al., (2011) also suggested graphical presentation of the assessment results as shown in figure 4. The sum grade of Main and Additional Values of every geosite individually are presented via X and Y axes respectively. Therefore, according to determined values gained by the assessment, every geosite could be put in one of the fields of this matrix. The matrix is further divided into nine fields (zones) that are indicated by Z (i,j) for (i,j=1,2,3) based on the grade they received in the previous evaluation process.

Table 4. The Additional Values of the GAM Model (according to Vujičić et al., 2011)

Additional Indicators / Sub-indicators	**Grades (0-1)**				
Grade	0	0.25	0.5	0.75	1
I Functional values (VFn)					
1. Accessibility	Inaccessible	Low (on foot with special equipment and expert guide tours)	Medium (by bicycle and other means of man-powered transport)	High (by car)	Utmost (by bus)
2. Additional natural values	None	1	2 to 3	4 to 6	More than 6
3. Additional anthropogenic values	None	1	2 to 3	4 to 6	More than 6
4. Vicinity of emissive centres	More than 100km	100 to 50km	50 to 25km	25 to 5km	Less than 5km
5. Vicinity of important road network	None	Local	Regional	National	International
6. Additional functional values	None	Low	Medium	High	Utmost
II Touristic values (VTr)					
1. Promotion	None	Local	Regional	National	International
2. Annual number of organised visits	None	Less than 12 per year	12 to 24 per year	24 to 48 per year	More than 48 per year
3. Vicinity of visitors centre	More than 50km	50 to 20km	20 to 5km	5 to 1km	Less than 1km
4. Interpretative panels (characteristics of text and graphics, material quality, size, fitting to surroundings, etc.)	None	Low quality	Medium quality	High quality	Utmost quality
5. Annual number of visitors	None	Low (less than 5000)	Medium (5001 to 10.000)	High (10.001 to 100.000)	Utmost (more than 100.000)
6. Tourism infrastructure (pedestrian pathways, resting places, garbage cans, toilets, wellsprings etc.)	None	Low	Medium	High	Utmost
7. Tour guide service (expertise level, knowledge of foreign language(s), interpretative skills, etc)	None	Low	Medium	High	Utmost
8. Hostelry service	More than 50 km	25-50 km	10-25 km	5-10 km	Less than 5km
9. Restaurant service	More than 25 km	10-25 km	10-5 km	1-5 km	Less than 1 km

Table 5. Overall ranking of Papuk mountain geosites using GAM

Geosite Label	Values				
	Main		Additional		Field
	VSE+VSA+VPr	∑	VFn+VTr	∑	
$GSPA_1$	4+3.75+3.50	11.25	4.75+8	12.75	Z_{33}
$GSPA_2$	3.5+3+3.25	9.75	4.75+8	12.75	Z_{33}
$GSPA_3$	2.5+3.5+3	9	3.5+7.25	10.75	Z_{33}
$GSPA_4$	2+3.25+2.25	7.5	3.5+5	8.5	Z_{22}
$GSPA_5$	2.5+2.25+2.75	7.5	4.5+7	11.5	Z_{23}
$GSPA_6$	2.25+3.75+2.25	8.25	3.75+5.25	9	Z_{32}
$GSPA_7$	3+2.75+2	7.75	3+8.75	11.75	Z_{23}
$GSPA_8$	1+2.5+2	5.5	2.75+5.5	8.25	Z_{22}
$GSPA_9$	1.75+2+1.25	5	2.75+6	8.75	Z_{22}
$GSPA_{10}$	2.25+2.50+2	6.75	4+7.5	11.5	Z_{23}
$GSPA_{11}$	2+2.25+3	7.25	4+7	11	Z_{23}
$GSPA_{12}$	2.25 +3+3.25	8. 5	2.75 +5.5	8.25	Z_{32}
$GSPA_{13}$	3+2.25+1.5	6.75	3.75+7.75	11.5	Z_{23}
$GSPA_{14}$	2+1.25+2	5.25	2.75+4.5	7.25	Z_{33}
Mean	-	7.57	-	10.25	-

Table 6. Overall ranking of Fruška Gora mountain geosites using GAM

Geosite Label	Values				
	Main		Additional		Field
	VSE+VSA+VPr	∑	VFn+VTr	∑	
$GSFG_1$	2+1.25+2	5.25	2.75+1.5	4.25	Z_{21}
$GSFG_2$	2.25+2.5+2.5	7.25	2.25+0.5	2.75	Z_{21}
$GSFG_3$	1.75+3.5+1.75	7	3+0.25	3.25	Z_{21}
$GSFG_4$	2.5+2.25+1.75	6.5	3.25+2	5.25	Z_{22}
$GSFG_5$	2.25+2.75+3.25	8.25	2.25+1	3.25	Z_{31}
$GSFG_6$	2.5+1.75+2.25	6.5	3.75+2	5.75	Z_{22}
$GSFG_7$	2.25+1.75+2	6	3+1	4	Z_{21}
$GSFG_8$	1+1.5+2	4.5	1.75+1.5	3.25	Z_{21}
$GSFG_9$	1.75+2.25+1.5	5.5	1.75+0.75	2.5	Z_{21}
$GSFG_{10}$	2.25+3+2	7.25	4+1.5	5.5	Z_{22}
$GSFG_{11}$	3.25+2.75+1.5	7.5	4+2	6	Z_{22}
$GSFG_{12}$	3.25 + 3.25 + 3.25	9.75	2.75 + 1.5	4.25	Z_{31}
$GSFG_{13}$	3.5+2.25+1.5	7.25	4+1.75	5.75	Z_{22}
$GSFG_{14}$	4 + 3.25 + 2.5	9.75	2.75 +1.5	4.25	Z_{31}
Mean	**-**	7.02	**-**	4.29	**-**

Major gridlines that create fields, for X axe have value of 4 and for Y axe of 5 units. This means that, for example, if sum of Main Values is 7 and of Additional Values is 4, the geosite would be in the field Z21 which indicates moderate level of Main Values and low level of Additional Values.

Figure 4 visually validates previous analysis of Main Values mean rank, as sites of both Papuk and Fruška Gora belong to fields Z(2,j) and Z(3,j) which proves the similarity and high significance of Main Values – geotourism and geoconservation potentials.

However, same figure (4) demonstrates evident difference of Additional Values between the two investigated destinations, as Papuk Mountain's geosites belong to fields Z(i,2) and Z(i,3) which confirms higher Additional Values than Fruška Gora whose ranks are mostly in lower fields of the matrix. The mean grade for Papuk is 10.25, which means that both, functional and touristic values are more developed than the values for Fruška Gora (4.29). This could be explained as results of management and planning in different types of protected areas. As Papuk Mountain is a geopark, more attention is given to geodiversity, while Fruška Gora is a National Park where much more interest is put on biodiversity. This initially lowers the status of geosites and their priority in terms of planning and management. Consequently, specific tourism values (VTr) related to geosites (geotourism) such as infrastructure, interpretation, georoutes and guided tours on Fruška Gora Mountain are poorly developed. This further pulls insignificant number of organised visits and thus the number of tourists on these sites. These values are more under the influence of human activities, so it definitely required considerable investments, which is certainly the case with Papuk Mountain, as this area has been more than five years under observation and consulting management of the Global Network of Geoparks.

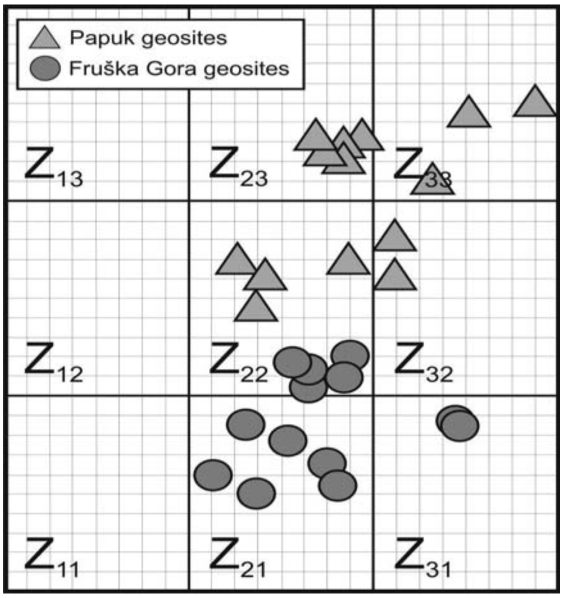

Figure 4. Dissemination of all inventoried geosites to certain fields according to GAM

It provides for this protected area much better propaganda at the global level as well as market recognition. Although geopark recognition does not in itself provide additional funds, it is under governmental institutes to provide well-developed tourist infrastructure and financial assistance in the execution of various activities in this area (resting places, visitor centres, guides, panels, etc.). Geopark designation of Papuk Mountain raises global awareness of the importance of geological conservation and contributes to the promotion of local and regional products that provides a great opportunity for introducing it to worldwide visitors.

However, there are several advantages of the Additional Values of Fruška Gora, in relation to Papuk Mountain that could be recognised as crucial in the future. These are certainly the better vicinities of emissive centres (two largest Serbian cities, Belgrade and Novi Sad, are less than 50 km away) and the main road (highways E75 and E70) and rail networks (Belgrade – Budapest – Vienna and Belgrade – Zagreb – Ljubljana – Trieste).

Also, surrounding anthropological heritage has undoubtedly Additional Value in favour of Fruška Gora. The attractiveness of the 16 orthodox monasteries, dating from the XVth to the XVIIIth century, fortifications (Petrovaradin Fortress, Tower of Vrdnik, etc.), the Tekije church, with the features of Catholic, Orthodox and Muslim influences and numerous monumental values (Vezirac, Brankov tomb, etc.), with diverse nature potentials, makes Fruška Gora a unique protected area in the region of Southeast Europe. Due to all of these facts Fruška Gora Mountain represents the main picnic and recreation areas in north Serbia. It is important to exert that there are many scientific and populist publications (Petković, et al., 1976; Knežević, 1998; Miljković, et al., 1998; Vasiljević & Marković, 1999; Marković, et al., 2001; 2004; 2006; 2007; Butorac, 2007; Habijan-Mikeš, 2007; Vujičić, et al., 2011) which indicate that there is significant public interest for this protected area. All these could highlight the considerable potential of this mountain and relevant dispositions for its future status as a global geopark.

5. CONCLUSION

The GAM model can significantly help further evaluation of the Main and Additional Values in the observed mountains. It may be noted that the Main Values are similar to both, Fruška Gora and Papuk. The first one has exceptional potentials, i.e. Main Values, which can significantly promote the possibility of obtaining geopark status. However, this protected area still has modest tourism values which are reducing the overall rating. On the other hand, Papuk Mountain, as a well developed Nature Park and global geopark, has high Main, and particularly, high Additional Values, with significant international recognition. These indicate that Papuk Mountain is a very good example of a protected natural area and should be an excellent model for future protection and development of various economic (touristic) segments of Fruška Gora Mountain.

It is important to note that management structure of Fruška Gora Mountain should necessarily improve its administration plan and attain a higher level of protection and sustainable development for the location. As these two investigated areas are less than 200 km away from each other, one of the development options could be collaboration of these complementary geotourism destinations through an international and mutual offer that could initiate new geo-destinations and further improve and develop conservation and promotion of geoheritage in a much wider region.

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