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Assessing speleoarcheological geoheritage: Linking new Paleolithic discoveries and potential cave tourism destinations in Serbia

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ABSTRACT

The aim of this paper is to perform a tourist assessment of the representative speleoarchaeological geoheritage in Serbia for the purposes of establishing new cave tourism destinations in Serbia. Seven caves have been selected based on their speleoarcheological values. However, only two of them are currently available for visiting. The research results were obtained by using the M-GAM model and they indicate exceptional tourist potential which still remains mainly untapped. To maximize this potential and develop this type of tourism in the future, an initiative strategy for the inclusion of speleoarchaeological values into contemporary tourism flows was also proposed. The focus is set on the establishment of speleoarchaeological visitor centers and a unique tourist affirmation of the researched scientific and educational potential. The presented strategy must be set as a priority in the future in order to contribute to further sustainability of scientific and socio-economic progress through speleotourism development.

1. Introduction

Archeology, anthropology and tourism share a common interest in the cultural identities of former civilizations and human communities. Scientists have been discovering new cultural resources for centuries, thus attracting human interest and stimulating mass curiosity. Many enthusiasts wanted to experience visual interaction with numerous archaeological and anthropological artifacts, and many local, regional and national authorities, as well as private companies around the world, recognised the possibility of tourist affirmation of scientific findings (Pacifico & Vogel, 2012). Tourist resources that have a historical, cultural and scientific connection with archeology and anthropology, and have experienced global recognition in the tourist market, are speleological objects. Caves are a unique natural tourist attraction and can be an indicator of cultural, scientific-educational and socio-economic development. According to Cigna (2016), caves gained great popularity and significant tourist development internationally in the early 1980s, when tourist caves (show caves) were visited by 26 million visitors. This was an important period

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for speleological objects because they were massively exploited for tourist and economic purposes, which created new challenges for the sustainability and protection of the cave ecosystem (Cigna, 2016; Tičar et al., 2018).

Caves are explored for the needs of various scientific fields. However, the analysis of caves from the aspect of archeology has shown exceptional research results for understanding the Paleolithic age. Paleolithic archeology is a scientific discipline that deals with the excavation and study of anthropogenic remains from the Paleolithic. During the Middle or Upper Paleolithic, humans began to produce various works of art (cave paintings, sculpture, jewelry etc.) and engage in religious behavior such as burial and ritual (Pettitt, 2008; Pettitt, 2013). Many of these anthropogenic Paleolithic activities were set in caves because they represented shelters from the harsh natural environment that man was facing at the time. Therefore, today, caves are of great importance for archaeologists and anthropologists alike because they represent focal sources of their scientific data on the Paleolithic period (Pettitt, 2008; Pettitt, 2013; Straus, 1990).

The anthropology of tourism has been considered a newly developed field in the mid-20th century. The main objective was to study the concept of tourism from all scientific viewpoints (Smith & Graburn, 1978). The emphasis has been on two topics: „the study of tourists and the nature of tourism itself, and the study of the social, economic and cultural impact of tourism on host populations and societies, including the nature of the host-tourist relationship"(Graburn, 1983). The interest in tourism among anthropologists has been developing slowly. Nevertheless, by the end of the 20th century, the anthropology of tourism was a well-established field, with promising signs for further expansion (Nash & Smith, 1991). Anthropologists and tourists have a lot in common since both commit to exploring the cultural knowledge and rituals of society and nature (Stronza, 2001). Since the travel industry is one of the world's largest enterprises, it has a significant and multifaceted impact on contemporary settings. Tourism affects various aspects of society, culture, traditions, but also natural landscapes and landforms. One form of tourism in which the application of anthropological theories may be especially pertinent is that of sustainable tourism (Burns, 2004). Cheng and Wu (2015) argue that sustainable tourism is strongly linked to anthropology because it encourages ethical and responsible behavior towards people, cultures, but also the protection and conservation of the natural environment.

Karst areas are an important segment of the natural environment that is particularly vulnerable and requires an exceptional level of protection. In addition to the protection of karst geomorphology, it is necessary to implement certain measures for the protection of cultural heritage, which is an integral part of karst regions. Anthropogenic values of karst are a direct consequence of the long-term interaction of people with these natural phenomena. Caves are especially prominent when it comes to the anthropogenic impact on karst areas. Prehistoric people especially used karst caves for basic living needs, hunting, fishing, shelter, etc. That is why they are the focus of many multidisciplinary studies, but also tourism affirmations. Tourism development must be carefully implemented in these areas, especially since Paleolithic values are thus exposed to potential threats. Therefore, it is necessary that tourism management structures apply only sustainable development strategies that should be compiled by a multidisciplinary team of experts.

Paleoanthropology is a branch of anthropology and paleontology that tries to understand hominin evolution and has exceptional relations with the tourism industry. Cave art, history museums and archaeological sites best reflect the inevitable connection between paleoanthropology and tourism. Anthropologists searching for the remains of prehistoric humans are making impressive discoveries, which are often the focus of many prehistoric enthusiasts but also of numerous curious tourists. For this reason, these two concepts can often be brought into the context of scientific-educational, cultural and economic symbiosis. Furthermore, many paleoanthropological fossil specimens are found in caves (e.g., Aubert et al., 2014; Aubert et al., 2018; Bae & Sanz, 2014; Berger et al., 2008; Chase, Debénath, Dibble, & McPherron, 2009; Hawks & Wolpoff, 2001; Klein, Cruz-Uribe, & Beaumont, 1991), which were frequently inhabited by ancient hominins. The findings, which are especially important for this paper, refer to the recent Paleolithic and paleoanthropological research results in Serbia (Lindal, Radović, Mihailović, & Roksandic, 2020; Mihailović, 2008; Mihailović et al., 2022, 2022; Radović, Lindal, Mihailović, & Roksandic, 2019; Roksandic et al., 2011; Roksandic, Radović, Lindal, & Mihailović, 2022).

The aim of this paper is to make an inventory of previous archaeological and paleoanthropological cave findings and to explore the possibilities for establishing new cave tourism destinations in Serbia. The research included a review of the latest anthropogenic cave artifacts and fossils found in Serbia. A tourist assessment of speleoarchaeological geoheritage for the needs of cave tourism development was conducted. The paper presents the idea of tourist arrangement and construction of visitor centers within five caves: Velika Balanica and Mala Balanica, Kozja, Pešturina and Šalitrena. Using the M-GAM methodological approach, the current state of the explored caves was determined, and the future perspectives of development and possibilities of tourist affirmation were also established.

2. Cave tourism in Serbia

Caves in Serbia are unique underground tourist attractions, which have a long tradition of tourist development thanks to the famous Serbian speleologist, Professor Radenko Lazarević. However, cave tourism did not achieve great success in terms of significant economic benefits at the national level. There are no appropriate management structures that implement the latest trends of cave tourism and the tourist traffic is not monitored within all cave tourism destinations. Moreover, determination of the show cave carrying capacity and potential limitation of the number of visitors in certain caves or parts of the caves was never conducted. These are major management obstacles that require immediate attention to establish a sustainable and geoethical identity for cave tourism in Serbia (Antić et al., 2020,b,c; Antić et al., 2022; Antić & Tomić, 2019; Antić, Tomić, & Marković, 2019; Tomić et al., 2019; Tomić & Marjanović, 2022; Vuković & Antić, 2019).

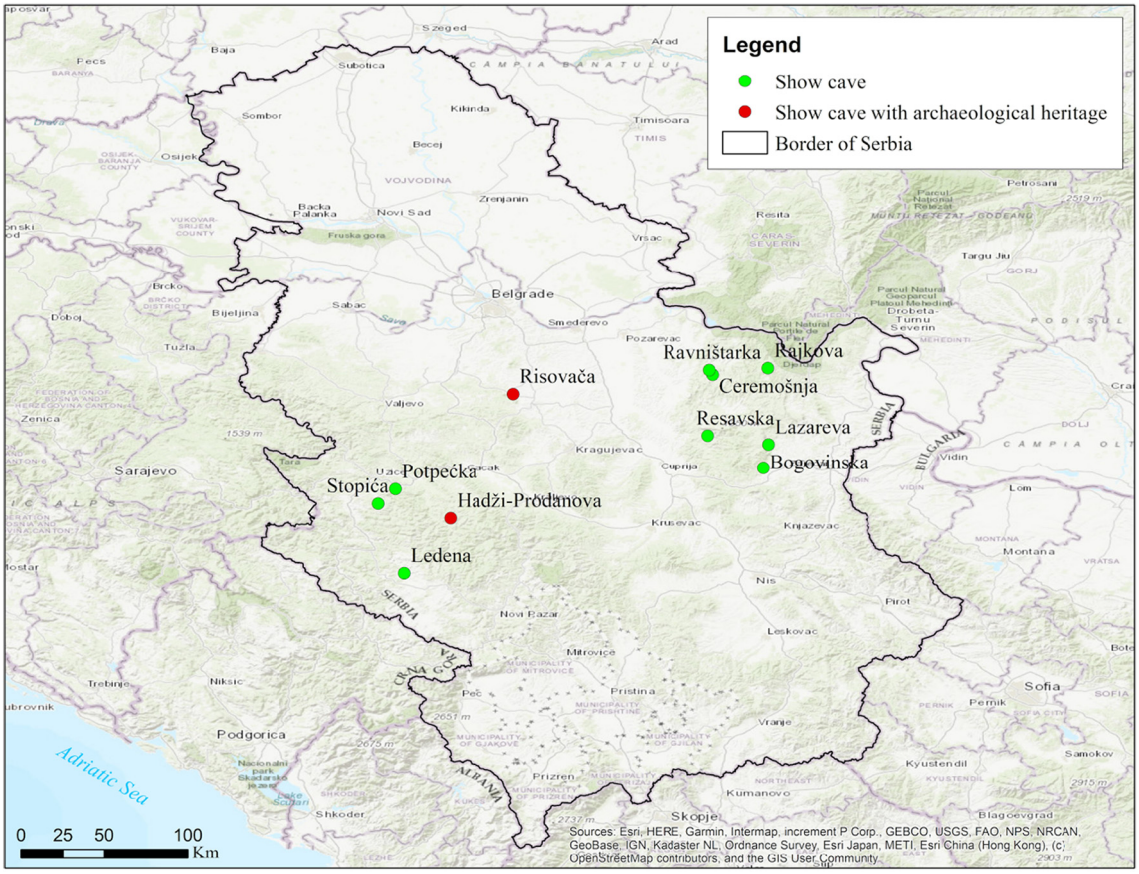

Fig. 1. Show caves in Serbia.

In 2018, the Resavska cave in Eastern Serbia had almost 60.000 tourists (according to the data of the Public Company "Resavska Cave"), and the management of the Stopića cave reported that they had 80.700 visits to the cave that year. Next year, the Hadži-Prodanova cave opened its door for visitors. Considering the archaeological significance of this cave, its tourist affirmation can significantly influence the enrichment of speleoarchaeological values on the tourist market. At the moment, a total of eleven show caves (Fig. 1) are open for tourist visits in Serbia: Resavska, Rajkova, Ceremošnja, Ravništarka, Risovača, Stopića, Potpećka, Lazareva, Bogovinska, Hadži-Prodanova and Ledena. Three more caves are available for visits via travel agencies, but only as a part of adventure and extreme tours: Cerjanska, Samar and Vladikine Ploče (Tourist Agency—Nature Travel Office). Overall, cave tourism, as well as adventure speleotourism is still poorly developed in Serbia and it requires a professional approach of stakeholders that would jointly influence the improvement of the entire speleological tourism product at the national level (Antić, Vujko, & Tomić, 2020).

Data on the number of visitors to show caves are shown in Table 1. Out of a total of 11 show caves available to tourists, for five of them, visitor numbers are monitored, while for others the data is not available. The data for Resavska and Stopića caves stand out significantly. In 2020, a total of 121.956 visitors visited the Stopića cave. This is the largest number of cave visitors in the history of cave tourism in Serbia. According to the presented data, a general trend of increase in visitor numbers is evident. However, those numbers are still at a lower value than in neighbouring countries such as Croatia or Slovenia (Tičar et al., 2018) but they also show that there is a strong potential for cave tourism and a necessity to improve these destinations and thus further increase tourist demand. However, in order to enable that, continuous work on the improvement of show cave tourist destinations is necessary along with the modernization and implementation of current trends (Tomić et al., 2019).

There are numerous caves that are not arranged for tourist visits, but still attract the attention of recreationists, mountaineers and professional speleologists. In the case of recreationists and mountaineers, it is a matter of sports and recreational speleotourism (or one-day excursions), while speleologists are also engaged in scientific research. On the other hand, certain caves also attract the attention of the wider scientific community, because they contain data that are of great importance for understanding scientific hypotheses and setting new research strategies. In particular, the caves of Mala and Velika Balanica, Kozja, Pešturina and Šalitrena have been the subject of research by archaeologists and paleoanthropologists for decades. The discoveries indicate exceptional scientific values, but also tourist potentials that can be turned into significant tourist resources.

Table 1
Tourist arrivals in show caves (2010−2020).

Years	Resavska	Rajkova	Risovača	Stopića	Potpećka	Total
2010	37,192	6,655	17,263	24,872	5,736	91,718
2011	36,470	5,427	19,171	29,310	5,336	95,714
2012	34,674	6,105	18,284	25,813	5,500	90,376
2013	36,260	5,145	23,402	27,690	5,106	97,603
2014	32,002	3,710	13,824	27,465	3,619	80,620
2015	41,667	4,729	21,006	29,001	4,788	101,191
2016	50,691	6,151	24,873	44,491	5,219	131,425
2017	57,209	7,074	25,041	61,262	7,013	157,559
2018	59,941	7,093	27,164	80,700	7,345	182,243
2019	63,251	7,971	34,603	89,113	7,712	202,650
2020	52,483	4,480	11,399	121,956	7,544	197,862
Total	501,840	64,540	236,030	561,673	64,918	1,429,001

Source: Cave Management Organizations.

3. Study area

The importance of the Balkan Peninsula for studying the early prehistory of Europe is based on its geographic position and ecological characteristics but also on the discoveries recorded so far. It is well-known that the central Balkans had a transitory character and represented a migrational corridor, which connected central and western Europe with southwest Asia. It is assumed that living conditions in the Balkans were more favorable, so the Peninsula played a role of an ecological refugium not only for plants and animals but also for human communities during the glacial periods. More recent investigations filled the gaps in our understanding of the early prehistory of this region and provided initial comprehension of cultural and technological development in the Balkan Paleolithic (Mihailović, 2014).

In this chapter, the most important speleoarchaeological sites in Serbia will be presented. Out of these seven caves, only two are currently arranged for tourist visits (Risovača and Hadži-Prodanova) while the rest are still not, although they possess speleoarchaeological heritage with exceptional potential for speleotourism affirmation and economic development in these parts of Serbia (Fig. 2). The two arranged show caves (Risovača and Hadži-Prodanova) were both geologically and archeologically examined in the past, while others were examined only archeologically. Their speleomorphological configuration is not known in the literature. However, these are all rather small caves, which do not represent complex speleomorphological units. The tourism infrastructure at the caves that are not arranged for visitation does not exist while the available rural roads are of very poor quality at the moment. These caves are not open for visits due to ongoing archaeological research. In addition to the tourism aspect, these sites can also become centers for the popularization and promotion of science. Moreover, it is very important to apply a sustainable development concept and include elements of geoethical values in order to implement maximum cave protection for present and future generations (Figs. 3–10).

3.1. Risovača Cave

The Risovača Cave (Fig. 3) is located at the entrance of Aranđelovac city, from the direction of Topola, in an old quarry on the steep right slope of the Kubršnica river. Its entrance is at an altitude of 230 m (i.e., set 16 m higher than the Kubršnica river bed). This speleotourist complex had long been cosnidered as one of the most important archaeological and paleontological sites in Serbia (Lazarević, 2008).

According to the locals, the existence of the cave was known even before the quarry started working (around 1937/38), but only two narrow entrances were known at that time. Therefore, it can be said that the cave was discovered when the stone exploitation began, around 1950. At the same time, the exploitation of the stone caused great damage to the cave, since the works destroyed the 20 m long cave entrance, and together with it, probably the richest speleoarchaeological cultural layer (Lazarević, 2008).

Numerous animal species were recorded at the cave entrance: cave bear (*Ursus spelaeus*), cave hyena (*Crocuta spelaea*), cave lion (*Panthera spelaea*), mammoth (*Mammuthus primigenius*), rhinoceros (*Dicerorhinus* sp.), bison (*Bison* sp.), auroch (*Bos primigenius*), horse (*Equuscaballus*), deer, rhino and others. The most numerous are the remains of cave bear (2/3 of the complete faunal assemblage), followed by those of the wild horse. The recorded fauna is mainly of the steppe type, from the warmer periods of the Late Pleistocene when the steppes from the Pannonian lowlands penetrated far into the interior of what is now known as the territory of Central Serbia (Dimitrijević, 1997).

The remains of the material culture of Paleolithic humans were also discovered at the entrance of the cave, and according to Gavela (1969) they belong to the Middle Paleolithic Szeletian technocomplex. The presence of bifacially retouched leaf-points indicates that the Szeletian technocomplex had been widespread not only in Central Europe but also in the northern parts of the Central Balkans (Mihailović & Zorbić, 2017).

The Risovača hominins (probably Neanderthals) lived in the entrance part of the cave, the part that was not covered with river sediment. However, since the real entrance to the cave was crushed during the stone exploitation, the main Paleolithic habitation

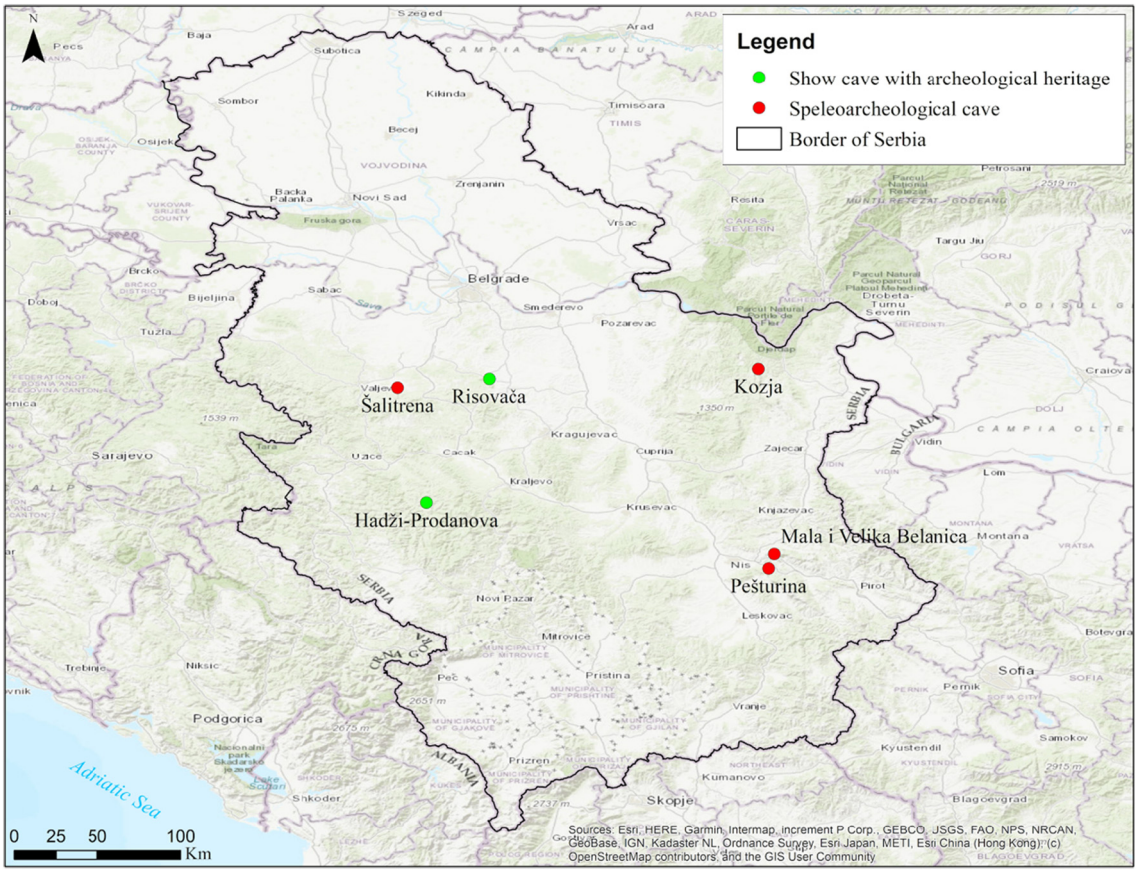

Fig. 2. Speleoarchaeological sites in Serbia.

was destroyed, and with it, potentially the most valuable speleoarcheological remains from the Paleolithic of Serbia. No hominin fossils have been discovered (Lazarević, 2008).

3.2. Hadži-Prodanova Cave

Hadži-Prodanova Cave (Fig. 4) is located in southwestern Serbia, on the territory of the municipality of Ivanjica, near the village of Šume, on the right bank of the Ršćanska river. In front of the cave there is a small memorial church built by Hadži Prodan (Hadži Prodan Gligorijević, the Duke of the First Serbian Uprising), and later renewed by the locals in honor and glory of Hadži Prodan's revolt against the Ottoman Empire (Lješević, 2002).

Fig. 3. Risovača Show Cave.

Fig. 4. Hadži-prodanova Show Cave.

Due to its good accessibility, the cave has long been of interest to scientists and researchers. The famous Serbian geographer Jovan Cvijić visited the Hadži-Prodanova Cave in 1914 and published a short article about it. The cave is characterized by a complex morphology with several side canals on different levels. A special feature of the cave lies in its composition with several narrowings and large shape expansions of the cave halls. Based on this, the following speleomorphological units can be distinguished: the Entrance canal, Narrowing, Central hall, Southside canal, East hanging canal, High canal with tubs, Long gallery and the Last hall. The total length of the explored canals of Hadži-Prodanova cave is 420 m (Lješević, 2002).

During the archaeological excavations conducted in 2003 and 2004, several layers containing Paleolithic material were explored in Hadži Prodanova Cave. Layer 2, dated to a wide range of 22.400–29.569 cal BP (Alex, Mihailović, Milošević, & Boaretto, 2019), yielded artifacts attributed to the Gravettian, while Layers 5a–5c contained Middle Paleolithic lithic artifacts. The upper part of Layer 5 (5a) was dated via the ^{14}C method to between >49.920 cal BP and 42.510 cal BP (Alex et al., 2019). Based on the remains of small mammals, the Middle Paleolithic strata were accumulated during a period of relatively mild and humid climate, most likely during MIS 3 (Bogićević et al., 2017).

About a hundred Middle Paleolithic artifacts made of chert and quartzite were found in Layers 5a–5c (Mihailović & Mihailović, 2006). Quartzite tools were produced by Neanderthals on the spot, while chert tools (Levallois blades etc.) were brought to the cave from some distance. The faunal assemblage is dominated by the bones and teeth of the cave bear (*Ursus spelaeus*), and the recorded remains of ibex (*Capra ibex*), chamois (*Rupicapra rupicapra*), deer (*Cervus elaphus*) and auroch (*Bos primigenius*) probably represent the remains of hunted prey. All this indicates that Hadži Prodanova Cave represented a temporary camp for Neanderthal groups that inhabited the mountainous area of the Eastern Dinarides during MIS 3.

3.3. Velika and Mala Balanica caves

The Balanica Cave complex is located in Sićevo, close to the city of Niš, and consists of Velika and Mala Balanica (Fig. 5 & Fig. 6). In Velika Balanica, six cultural horizons were examined, which contain numerous remains of fauna, knapped stone artifacts

Fig. 5. Mala Balanica Cave.

and traces of fire, indicating long-term and/or frequent settlement. For Layers 3a–3c, which yielded most of the lithic artifacts, two thermoluminescence (TL) dates were obtained: 285 ± 34 ka and 295 ± 74 ka. In Mala Balanica, a small number of artifacts were found only in the upper layers (2a–2c), dated via ESR in the period before 208–271 ka (Mihailović, Kuhn, et al., 2022), while in the lower layers, only the bones of bears, hyenas and other predators, as well as those of their prey, were discovered (Mihailović, 2008a; Mihailović & Bogićević, 2016a, 2016b; Mihailović, Kuhn, et al., 2022).

In 2006, one of the deepest layers of Mala Balanica (3b), where no remains of material culture were recorded previously, yielded a fragmented hominin mandible (designated BH-1) with three preserved molars (m1–3). The human fossil was found during regular excavations, along with the remains of wolves (*Canis* sp.), bears (*Ursus* sp.), cave hyenas (*Crocuta spelaea*), deer (*Cervus elaphus*), fallow deer (*Dama dama*) and ibex (*Capra ibex*). The BH-1 specimen displays mostly primitive morphology (both mandibular and dental) with the complete lack of derived Neanderthal traits, which is why it was initially classified as *Homo* sp. (Roksandic et al., 2011), and later reclassified as *Homo bodoensis* (Roksandic, Radović, Wu, & Bae, 2022).

Thousands of artifacts were found in the upper layers of Velika Balanica (2a–2c, 3a–3c), as well as a significant amount of mostly highly fragmented animal bones (Mihailović, Kuhn, et al., 2022). In Layers 2b and 3b, a high concentration of combustion traces was recorded, while in the lower part of Layer 3c (3c2), a zone of intense burning, 4–5 m in diameter, was found. In Layers 2a–2c of Mala Balanica about a hundred artifacts made of quartz, chert and chalcedony were registered, together with the remains of fauna, which are distinctly better preserved than in Velika Balanica. For now, everything points to the assumption that Velika Balanica was a base camp, and that Mala Balanica was inhabited only occasionally, for the purpose of butchering and slicing the

Fig. 6. Velika Balanica Cave.

Fig. 7. Kozja Cave.

captured prey. Among the remains of fauna, the bones of ibex and deer predominate in both caves (Mihailović, Kuhn, et al., 2022). Recently, the Middle Pleistocene (Chibanian) layers of Velika Balanica have also yielded hominin fossils (Radović, Lindal, Mihailović, & Roksandic, 2020; Roksandic, Lindal, Radović, & Mihailović, 2019, 2020), belonging to an early Neanderthal population (Roksandic, Radović, Lindal, & Mihailović, 2022).

The lithic industry from Layers 3a–3c of Velika Balanica and Layers 2a–2c of Mala Balanica is characterized by the presence of characteristic Quina sidescrapers, naturally-backed knives and other tools, including perçoirs and denticulated pieces. The Balanica lithic industry shows most similarities with the Acheulo-Yabrudian complex of the Levant, indicating that the emergence of Middle Eastern elements in the Balkans was due to population movements or cultural transmission from that area.

3.4. Kozja Cave

Kozja (Fig. 7) and Mala caves belong to the Beli izvorac cave system near Majdanpek (eastern Serbia), which is registered as a natural monument. Located at the foot of Mali Krš Mt., below the Straža peak, Kozja Cave represents a spacious speleological object: the entrance to the cave is 7.7 m wide and 3 m high, while the main hall is 35 m long (Lazarević, 1998). Archaeological excavations of the cave began in 2019, and continued in 2020 and 2021. Upper Paleolithic artifacts were found on the surface of Layer 2, while Middle Paleolithic artifacts were collected in Layer 2a2, together with the remains of a cave bear and other Pleistocene fauna. The same layer also yielded a human mandibular fragment, a detailed analysis of which is currently under way (Roksandic et al., 2020).

3.5. Pešturina Cave

Pešturina Cave (Fig. 8) is located northwest of the village of Jelašnica, on the northern foothills of the Suva Planina Mt.. During the course of archaeological excavations, conducted in 2006, 2008 and 2010–2021 (Mihailović, Milošević, et al., 2022), an extensive dating program was implemented, which included the application of ^{14}C, OSL and ESR methods (Alex et al., 2019; Mihailović, Milošević, et al., 2022).

In the cave, up to a depth of almost 5 m, three Middle Paleolithic horizons were examined. Hundreds of artifacts and many animal bone fragments were found in Layer 3. In Layer 4, a slightly larger number of artifacts was collected, but also a significantly larger amount of faunal remains; the layer was subdivided into four horizons (4a–4d). ESR dating has shown that Layer 3 was deposited 38–40 thousand years ago (37.8 ± 2.0 ka) and to correspond to Marine Isotope Stage (MIS) 3. For Layer 4a, a

Fig. 8. Pešturina Cave.

somewhat later date was obtained (73.3 ± 10.3 ka), which indicates that the upper part of the sequence may have been deposited in MIS 4, for which there is still no confirmation. For the same layer, and especially for horizon 4b, a whole series of dates were obtained, which indicates that 4b is about 111 thousand years old, which corresponds to MIS 5e–5c (Mihailović, Milošević, et al., 2022). In the set from Layer 4 (4a–4b), quartz artifacts predominate, and a smaller number is made of flint and quality chalcedony. The lithic industry from Layer 4 of Pešturina was attributed to the Charentian of Southeast Europe (Mihailović, Milošević, et al., 2022). This layer also yielded a find of the cervical vertebra of a cave bear with incised subparallel lines, which could be a testimony to the graphic expression of Neanderthals (Majkić, d'Errico, Milošević, Mihailović, & Dimitrijević, 2017).

Various remains of Pleistocene fauna have been collected from the Middle Paleolithic layers of the Pešturina Cave. In Layer 4, the most numerous are the remains of horses (*Equus* sp.) and bison (*Bison priscus*), while the bones of ibex (*Capra ibex*) and deer (*Cervus elaphus*) are less represented. The remains of rhinos (Rhinoceridae) and mammoths (*Mammuthus primigenius*) have also been found. The structure of the fauna in Layer 3 is not significantly different, except that they were not found remnants of megafauna (rhino, mammoth). Based on the number of hyena remains, the manner of bone fragmentation and the traces of teeth on the bones, it can be assumed that the main accumulator of remains in the cave in this period was the hyena (*Crocuta spelaea*) (Milošević, 2020).

In 2019, the find of a single hominin maxillary molar was announced (Radović et al., 2019). The tooth originated from Layer 4b of Pešturina, with an estimated age of 110.5 ± 11.1 ka and associated with Mousterian lithic assemblage (Mihailović, Milošević, et al., 2022). Most importantly, the molar displays a set of "classical" Neanderthal morphological features, making this find the first direct confirmation for the presence of *Homo neanderthalensis* in the Pleistocene of Serbia (Radović et al., 2019). Additionally, a partial atlas vertebra (attributed to an anatomically modern human) and a fragment of the radial diaphysis of a juvenile (possibly Neanderthal) individual were also recorded (Fig. 9) at Pešturina (Lindal et al., 2020). These finds have upgraded the Pešturina Cave into one of the most important paleoanthropological sites in Serbia.

3.6. Šalitrena Cave

Šalitrena Cave (Fig. 10) is located on the coast of the Ribnica river, near the Brežđe village (Mionica municipality) in Western Serbia. It represents one of the richest multi-layered Paleolithic sites in Serbia. About 2000 artifacts have been collected from the Gravettian Layer 5 and more than 10,000 artifacts have been collected from Layer 4. In Layer 3, which also contains the Gravettian industry, several hundred findings were discovered (Mihailović, 2008; Mihailović, 2013; Mihailović & Mihailović, 2007). Numerous Middle Paleolithic artifacts have been found in Layers 6a–6d (Marin-Arrojo & Mihailović, 2017; Mihailović, 2017).

According to several ^{14}C dates, the Layer 4 was dated to between 29,7–27,6 ka cal BP (Marin-Arroyo, Jones, Cristiani, & Stevens, 2022). In addition to knapped artifacts, fragments of bone tools, pigments and dental beads were also found in this layer. The entire layer, the thickness of which does not exceed 10 cm, is intensely colored with combustion particles. Preliminary analyzes have shown that different types of quality flint were used to make the tools, as well as magnesite from nearby deposits.

In Layer 5, which is radiometrically dated to about 31 thousand years ago, at least two fires were found, and beads made of *Dentalium* shells, fragments of bone tools and ocher lumps were also found. Artifacts made of low-quality gray flint from nearby

Fig. 9. Pešturina Cave - A layer in which Middle Paleolithic artifacts and Neanderthal remains have been found.

Fig. 10. Šalitrena Cave.

deposits predominate in the set, but there are also tools made of quality flint, which were probably transported from a greater distance. The industry is characterized by carinated endscrapers and burins, at least some of which are microlamellar cores. Artifacts made of low-quality raw materials are more frequent in the entrance part of the cave, while tools made on blades of somewhat larger dimensions also appear in the test-pit inside the cave. Spatial analysis of the remains indicated specific patterns in the settlement of the Šalitrena Cave during this phase (Plavšić, Dragosavac, & Mihailović, 2020).

Numerous Mousterian artifacts were found in Layer 6, which was dated to 43.9–38.5 ka cal BP (Mihailović, 2017). Artifacts retouched using discoid and Levallois technology are the most numerous among the primary knapping products, while sidescrapers predominate the tool assemblage. The most commom animal remains within the Aurignacian and Mousterian strata are bison and horses, while the remains of rhinos, deer, ibex and chamois were also recorded (Marin-Arrojo & Mihailović, 2017). The animal remains from the Gravettian layer will be published soon (Marin-Arroyo et al., 2022).

4. Methodology

Studies associated with the assessment of geoheritage are relatively young and fast-growing. The assessment of geoheritage is a crucial step in the process of geotourism development (Reynard, 2008), and it is widely accepted as a tool for the effective protection, development, and management of geological heritage (Suzuki & Takagi, 2018). Tourism assessment methodologies have been constantly developing during the last two decades. The methodology applied in this paper is based on the M-GAM model (Modified Geosite Assessment Model) developed by Tomić and Božić (2014). This method represents a mix of previous geosite assessment methods (Bruschi & Cendrero, 2005; Coratza & Giusti, 2005; Erhartič, 2010; Pereira, Pereira, & Caetano Alves, 2007; Pralong, 2005; Reynard, 2008; Reynard, Fontana, Kozlik, & Scapozza, 2007; Serrano & González-Trueba, 2005; Vujičić et al., 2011; Zouros, 2007) and is based on the Importance factor (Im) introduced by Tomić (2011). The Importance factor provides greater objectivity in the assessment process and provides more accurate results taking into consideration also the preferences of tourists instead of only experts. It has also been used in the creation of spa assessment (Tomić & Košić, 2020) and cultural route evaluation models (Antić, Tomić, Đorđević, & Marković, 2021; Božić & Tomić, 2016). The M-GAM methodological approach was successfully applied many times for the assessment of geoheritage in Serbia, Hungary, Iran, India, Slovenia and USA (Antić et al., 2019; Antić et al., 2020,c; Antić et al., 2022; Antić, Peppoloni, & Di Capua, 2020; Antić & Tomić, 2017; Antić & Tomić, 2019; Božić & Tomić, 2015; Božić, Tomić, & Pavić, 2014; Bratić, Marjanović, Radivojević, & Pavlović, 2020; Jonić, 2018; Mahato & Jana, 2021; Marjanović et al., 2022; Marjanović, Tomić, Radibojević and Marković, 2021; Milenković, 2021; Pál & Albert, 2018; Pál & Albert, 2021; Tičar et al., 2018; Tomić et al., 2015; Tomić et al., 2019; Tomić, Marković, Antić, & Tešić, 2020; Tomić, Sepehriannasab, Marković, Hao, & Lobo, 2021; Vukoičić, Milosavljević, Valjarević, Nikolić, & Srećković-Batoćanin, 2018; Vuković & Antić, 2019).

The M-GAM model comprises of two key indicators: main values (MV) and additional values (AV), which are further divided into 12 and 15 subindicators, each of them individually marked in a discrete way from 0 to 1. The division is based on two general types of values: main values (mostly originating from the geosite's natural attributes), and additional values (originating from human-induced factors). The main values are further divided into three groups of subindicators: scientific/educational (VSE), scenic/aesthetical values (VSA), and protection (VPr) values. Furthermore, additional values are also divided into two groups of subindicators, functional (VFn) and touristic values (VTr). A detailed list of all subindicator groups is presented in Table 2. As it can be seen in the mentioned table, there are 12 subindicators of main values, and 15 subindicators of additional values. Each of the subindicators is rated by experts and tourists on a five-point scale ranging from 0 to 1 (0, 0.25, 0.5, 0.75, 1). According

Table 2
The structure of the M-GAM model.

Indicators/Sub-indicators			Description
Main values (MV)	Scientific/Educational values (VSE)	1. Rarity ($SIMV_1$)	Number of closest identical sites.
		2. Representativeness ($SIMV_2$)	Didactic and exemplary characteristics of the site due to its own quality and general configuration.
		3. Knowledge on geoscientific issues ($SIMV_3$)	Number of written papers in acknowledged journals, thesis, presentations and other publications.
		4. Level of interpretation ($SIMV_4$)	Level of interpretive possibilities on geological and geomorphologic processes, phenomena and shapes and level of scientific knowledge.
	Scenic/Aesthetic values (VSA)	5. Viewpoints ($SIMV_5$)	Number of viewpoints accessible by a pedestrian pathway. Each must present a particular angle of view and be situated less than 1 km from the site.
		6. Surface ($SIMV_6$)	Whole surface of the site. Each site is considered in quantitative relation to other sites.
		7. Surrounding landscape and nature ($SIMV_7$)	Panoramic view quality, presence of water and vegetation, absence of human-induced deterioration, vicinity of urban areas, etc.
		8. Environmental fitting of sites ($SIMV_8$)	Level of contrast to nature, contrast of colours, appearance of shapes, etc.
	Protection values (VPr)	9. Current condition ($SIMV_9$)	Current state of geosite.
		10. Protection level ($SIMV_{10}$)	Protection by local or regional groups, national government, international organizations, etc.
		11. Vulnerability ($SIMV_{11}$)	Vulnerability level of geosite.
		12. Suitable number of visitors ($SIMV_{12}$)	Proposed number of visitors on the site at the same time, according to surface area, vulnerability and current state of geosite.
Additional values (AV)	Functional values (VFn)	13. Accessibility ($SIAV_1$)	Possibilities of approaching the site.
		14. Additional natural values ($SIAV_2$)	Number of additional natural values in the radius of 5 km (geosites also included).
		15. Additional anthropogenic values ($SIAV_3$)	Number of additional anthropogenic values in the radius of 5 km.
		16. Vicinity of emissive centres ($SIAV_4$)	Closeness of emissive centres.
		17. Vicinity of important road network ($SIAV_5$)	Closeness of important road networks in the radius of 20 km.
		18. Additional functional values ($SIAV_6$)	Parking lots, gas stations, mechanics, etc.
	Touristic values (VTr)	19. Promotion ($SIAV_7$)	Level and number of promotional resources.
		20. Organized visits ($SIAV_8$)	Annual number of organized visits to the geo-site.
		21. Vicinity of visitors centres ($SIAV_9$)	Closeness of visitor centre to the geo-site.
		22. Interpretative panels ($SIAV_{10}$)	Interpretative characteristics of text and graphics, material quality, size, fitting to surroundings, etc.
		23. Number of visitors ($SIAV_{11}$)	Annual number of visitors.
		24. Tourism infrastructure ($SIAV_{12}$)	Level of additional infrastructure for tourists (pedestrian pathways, resting places, garbage cans, toilets, etc.).
		25. Tour guide service ($SIAV_{13}$)	If exists, expertise level, knowledge of foreign language(s), interpretative skills, etc.
		26. Hostelry service ($SIAV_{14}$)	Hostelry service close to geo-site.
		27. Restaurant service ($SIAV_{15}$)	Restaurant service close to geo-site.

Grades (0–1)				
	0.00	0.25	0.50	0.75	1.00
1.	Common	Regional	National	International	The only occurrence
2.	None	Low	Moderate	High	Utmost
3.	None	Local publications	Regional publications	Nacional publications	International publications
4.	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
5.	None	1	2 to 3	4 to 6	More than 6
6.	Small	–	Medium	–	Large

(continued on next page)

Table 2 *(continued)*

Grades (0–1)					
7.	–	Low	Medium	High	Utmost
8.	Unfitting	–	Neutral	–	Fitting
9.	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
10.	None	Local	Regional	National	International
11.	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
12.	0	0 to 10	10 to 20	20 to 50	More than 50
13.	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)
14.	None	1	2 to 3	4 to 6	More than 6
15.	None	1	2 to 3	4 to 6	More than 6
16.	More than 100 km	100 to 50 km	50 to 25 km	25 to 5 km	Less than 5 km
17.	None	Local	Regional	National	International
18.	None	Low	Medium	High	Utmost
19.	None	Local	Regional	National	International
20.	None	Less than 12 per year	12 to 24 per year	24 to 48 per year	More than 48 per year
21.	More than 50 km	50 to 20 km	20 to 5 km	5 to 1 km	Less than 1 km
22.	None	Low quality	Medium quality	High quality	Utmost quality
23.	None	Low (less than 5000)	Medium (5001 to 10 000)	High (10 001 to 100 000)	Utmost (more than 100 000)
24.	None	Low	Medium	High	Utmost
25.	None	Low	Medium	High	Utmost
26.	More than 50 km	25–50 km	10–25 km	5–10 km	Less than 5 km
27.	More than 25 km	10–25 km	10–5 km	1–5 km	Less than 1 km

to this data, we can now define M-GAM as a simple equation:

$$\mathrm{M-GAM} = \mathrm{MV} + \mathrm{AV} \tag{1}$$

Since MV and AV consist respectively f three and two groups of indicators, these are their two equations:

$$\mathrm{MV} = \mathrm{VSE} + \mathrm{VSA} + \mathrm{VPr} \tag{2}$$

$$\mathrm{AV} = \mathrm{VFn} + \mathrm{VTr} \tag{3}$$

Each group of indicators consists of several subindicators, so Eqs. (2) and (3) can be written as follows:

$$\mathrm{MV} = \mathrm{VSE} + \mathrm{VSA} + \mathrm{VPr} \equiv \sum_{i=1}^{12} \mathrm{SIMV}i, \text{where } 0 \le \mathrm{SIMV}i \le 1 \tag{4}$$

$$\mathrm{AV} = \mathrm{VFn} + \mathrm{VTr} \equiv \sum_{j=1}^{15} \mathrm{SIAV}j, \text{where } 0 \le \mathrm{SIAV}j \le 1 \tag{5}$$

Values SIMV_i and SIAV_j represent 12 sub-indicators of main values ($i = 1, \ldots, 12$) and 15 subindicators ($j = 1, \ldots, 15$) of additional values. The main feature of M-GAM is that it focuses on both expert and visitor opinion. The experts rate each of the subindicators in the model and their grades are then multiplied with those of visitors (tourists) who also rate each of the subindicators. However, visitors only rate the importance of each subindicator in the model, not the subindicator itself. This is done through a survey where a list of all 27 subindicators is presented to the respondents (tourists) who are asked to rate the importance of each subindicator (Table 3). The visitor grades are then added up for each subindicator in the model and the mean value of each subindicator represents the importance factor (Im) for that subindicator. Each subindicator now has an importance factor (determined by tourists) which is then multiplied with the grades of experts (for each subindicator) leading to the final assessment value for each subindicator in the model. The importance factor (Im) permits visitors to express their judgment about each subindicator in the model and to show how significant it is for them when choosing and deciding between several geosites that they wish to visit (Table 4).

According to this, the importance factor (Im) is defined as:

$$\mathrm{Im} = \frac{\sum_{k=1}^{K} \mathrm{Iv}_k}{K} \tag{6}$$

Table 3
Subindicator values given by experts for each analyzed geosite.

Indicators/Sub-indicators		Values given by experts							Im	Total values						
		GS_1	GS_2	GS_3	GS_4	GS_5	GS_6	GS_7		GS_1	GS_2	GS_3	GS_4	GS_5	GS_6	GS_7
Scientific/Educational values (VSE)	Rarity ($SIMV_1$)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.89	0.22	0.22	0.22	0.22	0.22	0.22	0.22
	Representativeness ($SIMV_2$)	0.50	1.00	0.25	0.25	0.25	0.25	0.25	0.79	0.59	0.79	0.20	0.20	0.20	0.20	0.20
	Knowledge on geoscientific issues ($SIMV_3$)	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.45	0.45	0.45	0.11	0.11	0.11	0.11	0.11
	Level of interpretation ($SIMV_4$)	1.00	1.00	0.50	0.50	0.50	0.50	0.50	0.85	0.64	0.85	0.43	0.43	0.43	0.43	0.43
Scenic/Aesthetic values (VSA)	Viewpoints ($SIMV_5$)	0.25	0.50	0.25	0.25	0.25	0.25	0.25	0.79	0.40	0.40	0.20	0.20	0.20	0.20	0.20
	Surface ($SIMV_6$)	0.50	0.75	0.00	0.00	0.00	0.00	0.00	0.54	0.27	0.41	0.00	0.00	0.00	0.00	0.00
	Surrounding landscape and nature ($SIMV_7$)	1.00	0.75	1.00	1.00	1.00	1.00	1.00	0.95	0.95	0.71	0.95	0.95	0.95	0.95	0.95
	Environmental fitting of sites ($SIMV_8$)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68
Protection values (VPr)	Current condition ($SIMV_9$)	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.83	0.62	0.62	0.62	0.62	0.62	0.62	0.62
	Protection level ($SIMV_{10}$)	0.75	0.75	0.00	0.00	0.00	0.00	0.00	0.76	0.57	0.57	0.00	0.00	0.00	0.00	0.00
	Vulnerability ($SIMV_{11}$)	0.50	0.75	0.75	0.75	0.75	0.75	0.75	0.58	0.44	0.44	0.44	0.44	0.44	0.44	0.44
	Suitable number of visitors ($SIMV_{12}$)	0.75	0.75	0.25	0.25	0.25	0.25	0.25	0.42	0.32	0.32	0.11	0.11	0.11	0.11	0.11
Functional values (VFn)	Accessibility ($SIAV_1$)	1.00	1.00	0.25	0.25	0.25	0.25	0.50	0.75	0.75	0.75	0.19	0.19	0.19	0.19	0.38
	Additional natural values ($SIAV_2$)	0.50	0.25	1.00	1.00	1.00	1.00	0.50	0.71	0.36	0.18	0.71	0.71	0.71	0.71	0.36
	Additional anthropogenic values ($SIAV_3$)	1.00	0.25	0.75	0.75	0.50	0.75	0.75	0.70	0.70	0.18	0.53	0.53	0.35	0.53	0.53
	Vicinity of emissive centres ($SIAV_4$)	0.25	0.25	0.75	0.75	0.50	0.75	0.25	0.48	0.12	0.12	0.36	0.36	0.24	0.36	0.12
	Vicinity of important road network ($SIAV_5$)	1.00	0.50	1.00	1.00	0.75	1.00	0.75	0.62	0.62	0.31	0.62	0.62	0.47	0.62	0.47
	Additional functional values ($SIAV_6$)	1.00	0.50	0.25	0.25	0.25	0.50	0.00	0.59	0.59	0.30	0.15	0.15	0.15	0.30	0.00
Touristic values (VTr)	Promotion ($SIAV_7$)	0.75	0.25	0.00	0.00	0.00	0.00	0.00	0.85	0.64	0.21	0.00	0.00	0.00	0.00	0.00
	Organized visits ($SIAV_8$)	1.00	0.75	0.00	0.00	0.00	0.00	0.00	0.56	0.56	0.42	0.00	0.00	0.00	0.00	0.00
	Vicinity of visitors centres ($SIAV_9$)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Interpretative panels ($SIAV_{10}$)	0.75	0.75	0.00	0.00	0.00	0.00	0.25	0.81	0.61	0.61	0.00	0.00	0.00	0.00	0.00
	Number of visitors ($SIAV_{11}$)	0.50	0.25	0.00	0.00	0.00	0.00	0.00	0.43	0.22	0.11	0.00	0.00	0.00	0.00	0.00
	Tourism infrastructure ($SIAV_{12}$)	0.50	0.25	0.00	0.00	0.00	0.00	0.00	0.73	0.37	0.18	0.00	0.00	0.00	0.00	0.00
	Tour guide service ($SIAV_{13}$)	0.75	0.50	0.00	0.00	0.00	0.00	0.00	0.87	0.65	0.44	0.00	0.00	0.00	0.00	0.00
	Hostelry service ($SIAV_{14}$)	1.00	1.00	1.00	1.00	0.50	0.50	0.75	0.73	0.73	0.73	0.73	0.73	0.37	0.37	0.55
	Restaurant service ($SIAV_{15}$)	1.00	0.75	0.75	0.75	0.50	0.75	0.50	0.78	0.78	0.59	0.59	0.59	0,39	0.59	0.39

Note: GS_1 – Risovača Cave; GS_2 – Hadži-Prodanova Cave; GS_3 – Velika Balanica Cave; GS_4 – Mala Balanica Cave; GS_5 – Kozja Cave; GS_6 – Pešturina Cave; GS_7 – Šalitrena Cave.

where Iv_k is the assessment/score of one visitor for each sub-indicator and K is the total number of visitors. Finally, the M-GAM equation is defined and presented in the following form:

$$M - GAM = MV + AV \tag{7}$$

Table 4
Overall ranking of assessed speleoarcheological sites in Serbia.

Geosites	Values				
	Main values	Overall	Additional values	Overall	Field
	VSE + VSA + VPr		VFn + VTr		
GS_1 – Risovača Show Cave	1.90 + 2.30 + 1.94	6.14	3.14 + 4.55	7.68	Z_{22}
GS_2 – Hadži-Prodanova Show Cave	2.31 + 2.19 + 1.94	6.45	1.83 + 3.28	5.11	Z_{22}
GS_3 – Velika Balanica Cave	0.96 + 1.83 + 1.16	3.95	2.55 + 1.32	3.87	Z_{11}
GS_4 – Mala Balanica Cave	0.96 + 1.83 + 1.16	3.95	2.55 + 1.32	3.87	Z_{11}
GS_5 – Kozja Cave	0.96 + 1.83 + 1.16	3.95	2.10 + 0.76	2.86	Z_{11}
GS_6 – Pešturina Cave	0.96 + 1.83 + 1.16	3.95	2.70 + 0.95	3.65	Z_{11}
GS_7 – Šalitrena Cave	0.96 + 1.83 + 1.16	3.95	1.84 + 1.14	2.98	Z_{11}

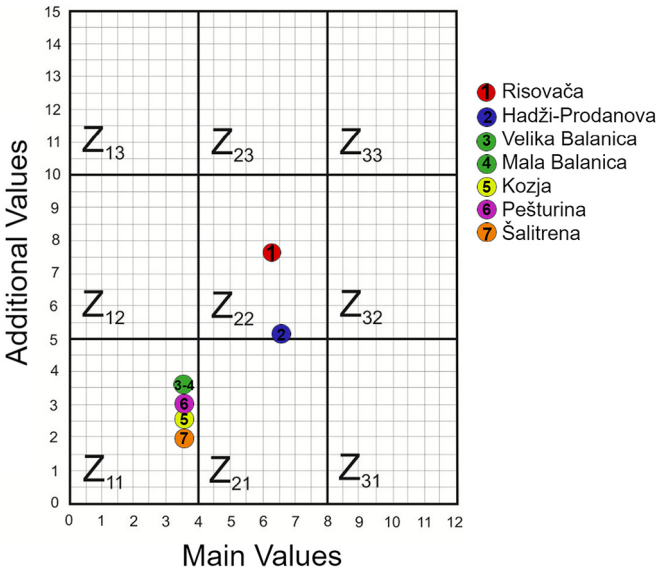

Fig. 11. Position of the analyzed geosites in the M-GAM matrix.

$$\mathrm{MV} = \sum_{i=1}^{12} \mathrm{Im}_i \times \mathrm{MV}_i \tag{8}$$

$$\mathrm{AV} = \sum_{j=1}^{15} \mathrm{Im}_j \times \mathrm{AV}_j \tag{9}$$

For the purpose of this research, the importance factor (Im) values were adopted from the work of Božić and Tomić (2015) who did the calculations in their geotourism study where they presented the Importance factor values of Serbian tourists for each subindicator in the M-GAM model.

Based on the obtained results and the sum of main and additional Values, a two-dimensional matrix presenting the final results of each analyzed geosite can be created (Fig. 11). The sums of main and additional values serve as coordinates for the *X* and *Y* axes of the M-GAM matrix and they determine the position of each analyzed site within the matrix. The matrix is divided into nine fields represented with $Z(i,j)$, $(i,j = 1,2,3)$. Depending on the final score, each geosite will fit into a certain field. For example, if a geosite's main values are 7 and additional values are 8, the geosite will fit into the field Z_{22}.

5. Results and discussion

Obtained results (Table 4 & Fig. 11) show that two of the assessed caves have relatively high main values (MV), Risovača (6.14) and Hadži-Prodanova (6.45). This is mostly due to the high score of scientific/educational values (SEV) and scenic/aesthetic values (SAV), as well as protection values (Pv). The Hadži-Prodanova Show Cave has the highest score for representativeness and level of interpretation as this cave has diverse speleothems and karst processes are visible and available for tourism interpretation. Other caves do not have speleothems, karst processes are poorly expressed, and they do not have publications related to a geoscientific issue on the international level, so they have a lower score of SEV. Geosites Hadži-Prodanova and Risovača are well designed show caves that occupy bigger surfaces in regard to other explored caves. Therefore, these show caves can accommodate a larger number of tourists at the same time without causing any damage to the site's interior and have more than two viewpoints presenting different angles of view. These caves are the only ones that have protected status as monuments of nature, thus they are protected on a national level.

Velika and Mala Balanica caves, Kozja Cave, as well as Pešturina Cave, are located within the protected areas, but the caves themselves do not have formal protection status. Šalitrena Cave, on the other hand, has the status of a cultural monument of great importance, whose competent institution for protection is the Institute for the Protection of Cultural Monuments. This is the result of extremely valuable archaeological findings that are changing the archaeological and anthropological knowledge of the Paleolithic era in Europe (Mihailović, 2014). All geosites have a high score for the surrounding landscape and nature, as they are located in a natural environment with pristine landscapes. This is quite significant given the fact that this subindicator is the most important (Im = 0.95) for Serbian geotourists. Hadži-Prodanova Show Cave has a slightly lower score for this subindicator due to an active quarry in the immediate proximity to the cave entrance. This is a big problem, which is primarily reflected in the endangerment of a cave bat colony present in the cave, but also in the general safety of this show cave. Such a

negative aspect of this show cave affects the identity of the destination and impairs its sustainability. Therefore, it is necessary to apply the principles of geoethical measures established by the competent experts within the International Association for the Promotion of Geoethics.

Analysing additional values (AV), it can be observed that the Risovača Show Cave (7.68) and Hadži-Prodanova Show Cave (5.11) have the highest score among the evaluated sites. This is mostly due to the high score of Functional values (VFn) and Tourist values (VTr). These caves are the only ones accessible by bus, thus bigger groups can visit them. Other caves are accessible only by foot, and the accessibility can be limited due to bad weather conditions, as tracks and paths leading to the caves can be slippery and muddy. Most of the assessed geosites are located in a highly attractive natural environment with many other attractions such as gorges, canyons, various rock formations, waterfalls, lakes and rivers. However, most of the sites are located in the vicinity of populated areas, and their anthropogenic values as well, such as churches, monasteries and local museums. When analysing the proximity of emissive centres, geosites Velika and Mala Balanica, as well as Pešturina Cave, are located less than 25 km away from the highly populated area in Serbia - the city of Niš (more than 250.000 inhabitants), which can be considered a significant convenience. The Risovača Show Cave is located within the town of Aranđelovac, near the international road of high importance, highway E-75 (A1), which connects central and northern parts with the southern parts of Europe. Geosites Mala and Velika Balanica, Pešturina, and Kozja caves are located near the important international road E-80 (A4), which connects Europe and Asia. Other geosites are located near roads of regional or local importance. Therefore, we can conclude that the position of all caves is generally favorable when it comes to accessibility, both for domestic and foreign tourists.

In the M-GAM, subindicators of touristic values (VTr) are highly rated by Serbian geotourists, so the improvement of these subindicators may contribute to a better tourist experience, destination image and tourism branding. When it comes to VTr, geosites Risovača (4.55) and Hadži-Prodanova (3.28) show caves have the highest score, while Kozja Cave (0.76) and Pešturina Cave (0.95) have the lowest score. This is the result of the fact that Risovača and Hadži Prodanova are active show caves that required a certain tourist infrastructure, necessary for visitation, while all other caves are not available for visits and do not have any kind of tourist infrastructure. Since the researched and evaluated speleoarchaeological sites do not represent the usual speleological objects that are suitable for the classic show cave tourism affirmation, it is necessary to direct further development on the construction of adequate thematic visitor centers within these potential speleoarchaeological tourist destinations. Unfortunately, none of the evaluated caves have visitor centers. Moreover, the promotion is crucial for bringing attractions closer and available to the public. Geosites Risovača and Hadži-Prodanova are promoted through the websites of local tourist organizations, as well as on the website of the National Tourism Organisation of Serbia, so these caves can be recognised as tourist attractions on both national and international levels. Other geosites are still not recognised as tourist attractions, so promotional activities are at a very low level. Besides Risovača and Hadži-Prodanova show caves, other explored caves do not have organized visits, and they are visited by a small number of tourists, mostly hikers and nature enthusiasts. Thus, the construction of visitor centers in the future could increase tourist traffic and tourist demand. Future tourism development and dissemination of geosciences, archeology and anthropology is very important, as visitors can experience adequate educational visits (both natural and cultural), buy tourist maps, brochures, souvenirs, and inquire about professional tour guide services. In the visitor centers, it is possible to organize various scientific and educational presentations, lectures, conferences, seminars, scientific congresses, and with the help of modern technology to provide visitors with a VR experience that would focus on reconstructions of Paleolithic culture in caves. In this way, a modernization of speleoarchaeological values would be carried out through the promotion of multidisciplinary scientific identity of caves and multiattractive elements that are important for tourists.

Specific forms of tourism, such as cave tourism, require highly trained tour guide service to make the tourist experience exceptional in terms of interpretation and education. Risovača and Hadži-Prodanova show caves provide a highly trained multilingual tour guide service, whose presentation brings science closer to the general public. The other caves do not have organized tour guide service. Interpretive panels should provide information about the site when there is no tour guide. The panels are usually useful for self-guided tours as they provide information about the path length, location, basic information, level of protection, etc. The Risovača Show Cave is the only evaluated site with high-quality interpretive panels (colored illustrations, level of protection, basic information about archeology, geology and geomorphology, the significance of the site and they are constructed of environmentally friendly materials). Other evaluated sites have low-quality panels (name of the location and level of protection) or no panels at all. Therefore, the basic factors of tourist infrastructure are missing on most of the analyzed sites.

There are numerous tourist destinations that have emerged as a direct consequence of speleoarchaeological values and research. Some of the most important are certainly Lascaux (France) and Altamira (Spain), but also Fumane Caves (Italy), Petralona (Greece), Krapina (Croatia), etc. These destinations have a large number of visitors and represent very important socio-economic factors at the local and regional level. Therefore, it is evident that there are speleoarchaeological destinations in the world with successful economic results. In Serbia, only two speleoarchaeological sites are available to tourists (Risovača and Hadži-Prodanova caves). However, the interpretation in Risovača is quite limited and there is no specific visitor center where visitors can get acquainted with the archeology of this cave. In the Hadži-Prodanova Cave, the archaeological aspect of storytelling is almost completely absent. Nevertheless, recent speleoarchaeological discoveries in Serbia that are presented in this paper, as well as previous discoveries, point to scientific values that are unique in the Balkans and very important for understanding the Paleolithic period in the European continent. Therefore, it is crucial to launch a sustainable form of affirmation of these scientific values for tourism purposes. Bearing in mind that the three analyzed caves (Mala and Velika Balanica and Pešturina) are located in the geologically attractive environment of Sićevačka gorge, and that these caves have impressive speleoarchaeological values mentioned in this paper, the potential of this area for building a speleoarchaeological visitor center is evident. The goal of such a

project is certainly the possibility for the mentioned scientific values to reach as many people as possible, all generations of scientists, researchers, tourists and enthusiasts.

Numerous studies indicate a growing trend in the use of virtual reality technology for tourism (Beck, Rainoldi, & Egger, 2019; Kim & Hall, 2019; Kim, Lee, & Jung, 2020; Wagler & Hanus, 2018; Yung, Khoo-Lattimore, & Potter, 2021). Kim and Hall (2019) state that VR technology should provide visitors with a variety of content, in order to keep visitors entertained for as long as possible with interpretive services at destinations. In the case of speleoarchaeological destinations, this can be done primarily through the reconstruction of Paleolithic living conditions in caves, video games, movies and the like. This ensures the diversity of tourist content that can inspire tourists to visit the destination again in the future.

With the exception of two show caves (Risovača and Hadži-Prodanova), which were evaluated within this paper, all of the other caves are not present in the tourist market, and they lack an adequate tourism management strategy that would direct further sustainable tourism development and adequate affirmation of science and education. Based on the obtained research results, however, it is possible to single out a crucial socio-economic strategy that is necessary for the modern affirmation of speleoarchaeological geoheritage tourism:

- Establish a unique multidisciplinary team of experts in the field of archeology, anthropology, geography, geology, spatial planning and tourism, and develop long-term goals for the affirmation of sustainable speleoarchaeological geotourism in Serbia;
- Integrate all stakeholders, and establish cooperation with national and local authorities, as well as with locals;
- Enable locals to sell products and services, and support sustainable local economic development;
- Launch an initiative to obtain conservation status for caves that are currently unprotected and continuously apply geoethical principles of protection;
- Conduct professional training of the guide service;
- Development of a framework for projects of visitor centers and museusm that will modernize speleoarchaeological geotourist destinations through modern technologies;
- Engage non-government organizations (NGOs), volunteers, nature and science enthusiasts to enrich social inclusion;
- Carry out active monitoring of visitors and continuous improvement of the image of the destination through the application of modern trends.

6. Conclusion

Archeology and tourism are often connected and represent a unique unification of science, human curiosity and economy. For a long time, they have been enabling people around the world to learn about the visible traces of human activities in order to get to know their content in a certain time and space, as well as their meaning in a certain social, economic and historical environment. Speleoarchaeology has a significant contribution to the understanding of the identity of Paleolithic people as well as migration and climatic events of that period. For that reason, speleoarchaeology has an authentic tourist potential that can be significantly affirmed on the tourism market, and turned into tourist values of great economic importance.

As a country located in the central part of the Balkan Peninsula, Serbia includes a large number of speleoarchaeological sites that can be affirmed for the needs of tourism development and the creation of new cave tourism destinations. The selected caves explored in this paper are of exceptional value to science and the general understanding of the Paleolithic, and are therefore a priority for popularization and inclusion in the tourism market. Moreover, it is necessary to carefully analyze and determine precautionary measures when exploiting the natural and anthropogenic potentials of these speleoarchaeological sites. First of all, it is necessary to establish a team of experts and professionals who would compile and implement the project objectives. Following the global trends in similar destinations, it is necessary to direct strategies towards the establishment of modern visitor centers and museums that would provide visitors with an adequate educational experience. In this way, general innovation would be introduced in terms of the diversity of tourist experiences when it comes to cave tourism.

Having in mind all of the mentioned speleoarchaeological values in Serbia, the potential for this type of tourism development is evident. However, the tourist infrastructure, additional functional values, as well as the basic initiative for this type of tourism development do not exist at the moment. This is the primary problem that needs to be addressed, in order to move the institutions towards the realization of such projects. Risovača and Hadži Prodanova caves are accessible to tourists, but their speleoarchaeological values have not been economically affirmed in the way it was conducted in a competitive environment (e.g. Krapina, Croatia). In addition, the presented speleoarchaeological values of the researched geoheritage have a rather rich assortment for tourist affirmation at the national level, which can potentially be branded and thus promoted on the European and/or world tourism market.

Credit authorship contribution statement

Aleksandar Antić: Conceptualization, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. **Dušan Mihailović:** Writing – original draft, Formal analysis, Validation. **Predrag Radović:** Writing – original draft, Formal analysis, Validation. **Nemanja Tomić:** Methodology, Writing – original draft, Writing – review & editing, Supervision. **Miloš Marjanović:** Writing – original draft, Formal analysis, Data curation. **Milica Radaković:** Visualization. **Slobodan B. Marković:** Writing – original draft, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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