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Investigation and Evaluation of Geological Diversity in Fahlyan Basin

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Abstract The world around us is very diverse physically, biologically, culturally, and so on. These diversities have provided us with many advantages so that by employing them, we can get short-term, long-term and sustainable benefits. Given the importance of the sustainable use of resources, it seems that the first step towards this purpose is identification and scientific study of these resources. Since 1990s, geologists and geomorphologists began to use the term geodiversity, which led to opening of a new direction in studies related to this subject. Given the importance of identifying potentials of geodiversity and the need for its conservation and sustainable use, this research aimed at analysis of geodiversity and its conservation and sustainable use. To this purpose, the study area based on its natural properties was divided into 3 classes. Then, for each of these classes, determinants features of geodiversity, including geology, hydrology, soil, etc., were investigated and the geodiversity index was calculated. The results showed that Class 1, located at the north of the basin, had the highest geodiversity index (6.59), mainly because of existence of calcareous formations and various geomorphologic forms, and the smallest index value (2.9) was calculated for the Class 3, which is mainly formed of alluvial deposits

Keywords : Geodiversity; Landscape; Fahlyan Basin; Geomorphology

1. Introduction

Geodiversity or geological diversity includes a variety of geomorphic and geological forms and ground-level phenomena such as stratigraphic diversity, petrologic diversity, sedimentologic diversity, and so on (Ghanavati et al., 2012). Gary (2004) believed that geological diversity should be protected for two reasons; first, geological diversities are valuable, and second, these diversities are threatened to a large extent by various human activities. These protections can be a means for measuring and differentiating people in modern civilized society, which naturally have to call for protection of geological attractions, because these attractions are both worthwhile and threatened. Gary (2005,

2013) believed that geological diversity includes a range of geological complications (rocks, minerals, and fossils), geomorphic complications (landforms, processes) and the soil and deals with their accumulation, relationship, properties, interpretations and systems. Martinez et al. (2008) considers geology as a natural variation in terms of number, distribution and frequency of elements and geological processes and believes that biodiversity is not similar to the geological diversity, but it depends on the location or area. Broussie and Sanderrow (2009) have a different definition, which is the sum of the components of the crust including rocks, geological structures, minerals, fossils, surface deposits, geomorphic classes and active processes, which provides useful materials and services for the human beings. Ramon Pilitero et al. (2010), considering abiotic aspects in evaluation and protection of natural diversity areas, investigated application of geodiversity and geomorphosites to introduce protected natural areas. Laura Comanche and Alexander Nedela (2012) used formulas proposed by Serrano and Ruiz Flano (2007) and Reynard (2008) to calculate geodiversity in the Buzali Kanti Geopark in Romania and based on these variations determined functionality of the geopark. Kozlowski (2007), emphasizing on reduction of landforms, evaluated geodiversity in southern Poland. Fasoulas et al. (2012) introduced a quantitative evaluation method for geosites, which can be used in sustainable management and conservation of the geological heritage of region. They were focused on development of specific indicators necessary to determine numerical values relating to the tourist and educational importance of geosite and the need to protect them.

Yazdi and Dabiri (2015) considered the geodiversity as a basis for geotourism and concluded that in study of geodiversity, intrinsic, cultural, aesthetic, economic, functional values as well as threats to this areas such as urbanization next to the geosites and plenty of visitors must be considered. In addition, managing geotourism in geoparks and related recreational activities should be adjusted and implemented in accordance with geological diversity. Studies carried out in Iran such as Shayan (2016) and Ansarifar et al. (2013) are more descriptively focused on importance geodiversity in the studied areas and no quantitative research was found in the literature.

Iran in terms of unique geological and geomorphological phenomena is one of the richest countries in the world and it has a great potential to achieve sustainable development in this way. According to forecasts, there are 50 potential areas for identification, establishment, exploitation of tourism, education and sustainable development in Iran that can be registered as a world geopark (Nekoei Sadri, 2011). The regional extent and many potentials existing in Iran can be employed to attract tourists to create money and jobs and provide sustainable development (Ghadirzadeh, 2007).

Given importance of geodiversity both in terms of visual beautifulness and tourist attraction as well as in terms of creating inherent potential and capacities, it seems that biodiversity is the first step to conservation and the optimize use of this natural talent. For this reason and given that the studied area, i.e. Fahlyan basin, both in terms of location and area and naturally has many potentials, this study aimed at quantitative study of geodiversity of the area.

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2. Research methodology

The present study was conducted using descriptive-analytical method to quantitatively study the geomorphologic phenomena and determine their relationship with topics of sustainable tourism development in the form of geotourism and geopark. This research descriptively and analytically uses the geodiversity index to investigate the biodiversity of the Fahlyan basin. To this purpose, the studied basin according to topography of the area was first divided into 3 classes (including mountains, pediment and plains). Then, topographic maps (with scale 1:50000) and geological maps were used to prepare a geomorphology map. DEM layer was used to provide slope layers, slope direction, roughness of terrain. Drain layer were used to determine drainage density and geological layer were used to prepare the lithology map and to determine the distance from the fault. In the end, by calculating the amount of roughness, counting the number of geomorphic elements in each class and dividing on the area of each class, the geodiversity index for each class was obtained using Equation (1):

$$Gd=Eg* R/Ln\ S \quad (1)$$

Where Gd is the geodiversity index, Eg is all the effective parameters in geodiversity, R is the roughness index, and S is the area of the desired class.

Table 1. Elements needed to calculate the geodiversity index

Element	Calculate index
Geology Linguistics Distance from fault	Variety of rocks per unit Extract the fault lines from the geological layer, b) Generate the compression layer in the GIS
Soil Soil classification	
Hydrography River type Hydrography Drainage density Waterline classification The direction of the river River slope	From the digital layer, the simulation of the basin was made and the type of waterways was identified in this way From the Channel Layer in the GIS environment, LINE DENCITY In the GIS environment In Arco Hydro From the Dem layer in the GIS environment From the Dem layer in the environment
Roughness	Using the DEM layer in the GIS environment
Geomorphology Landform Slope steep direction	Using a topography map of 1: 50000 and mosaicing layers using a shape curve, forms are extracted. Slope layer using the Demo layer Layer direction of gradient using Layer Dem

Location of the study area

The intended aquifer is located in the south-west slopes of Zagros Mountains, northwest of Fars province, south of Iran. The maximum altitude in the region is 2883 meters and its area is 1040 km^2, which with a northwest-southeast trend is placed between latitude 30°07′N to 30°28′ N and longitude 51°21′E to 51°49′E. The study area from north reaches to the Sepidan plain, from south reaches to Seranjelik area, from west to Noorabad plain, and from east to Yasuj basin. Figure 1 shows the geographic location of Fahlyan plain. The region climate is semi-arid. Figure (1).

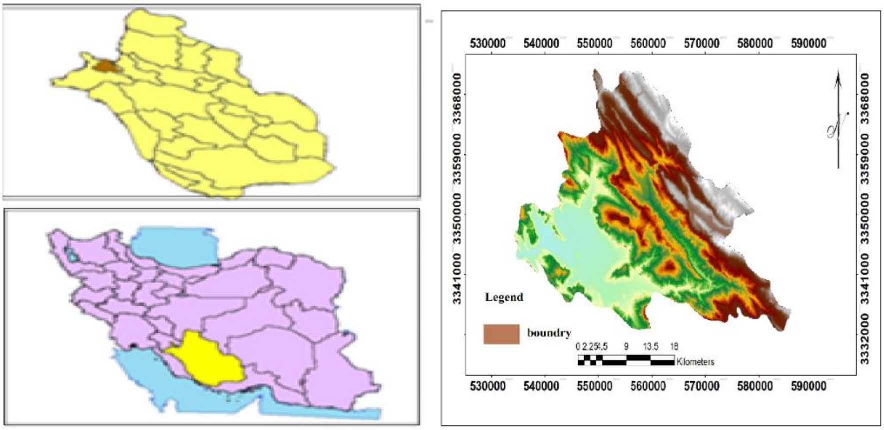

Figure 1. Position of study area

3. Results

As mentioned in the methodology, the basin in terms of topography was divided into top 3 Classes, called C1, C2, and C3. This categorization was to ease the quantifying process of geodiversity elements. In fact, the integrated analysis of effective elements in geodiversity such as height, slope, land use, slope direction, soil and lithology, each in the region has their own special significance. In addition, value of each of them according to their basic geology classification and matching on each of the layers and their calculation represents the value and importance of each class. Figures 2 through 11, in order, show functional characteristics, height, drainage network, drainage density, lithology soil, slope direction, slope amount, roughness and distance from the fault.

Investigating geomorphology and lithology of the region

Fig. 2 As the geomorphology map of the study area show, the river originates from the upstream and by passing hard karst areas and cutting through the stones creates river valleys and where the slope is very large, it has led to formation of huge slopes and abyss and where the slope is less, it has formed alluvial fans and in planes, the alluvial deposits has formed terraces and flat areas.

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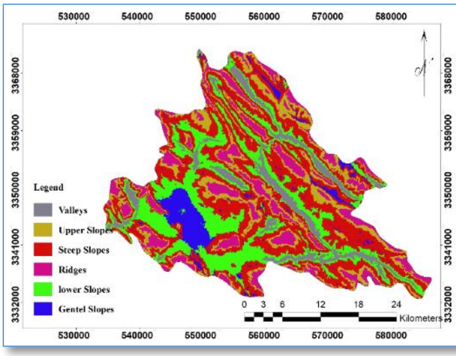


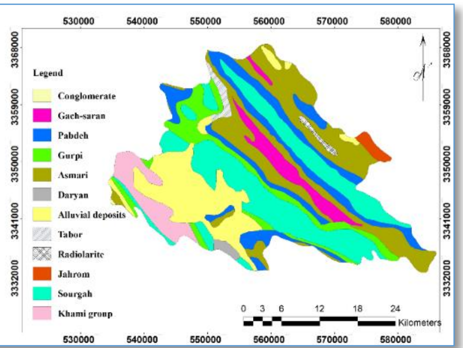
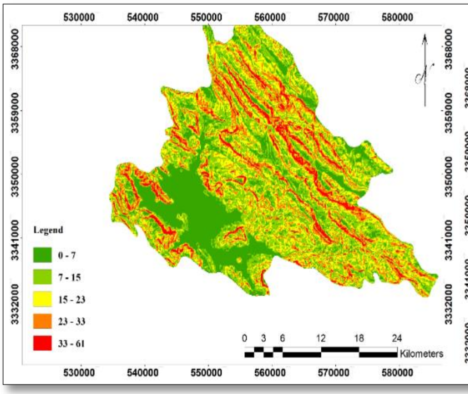


Figure 2. Geomorphology layer of Fahlian Figure 3. Lithology layer of Fahlian Basin

Slope and slope direction

Figure (4) In the Fahlyan basin, slopes greater than 23 degrees are mostly located in northern and northeastern areas, which have caused formation of many geomorphologic forms and have contributed to geodiversity form in the region, but as the height decreases, the slope is also reduced and variety of forms is much less.



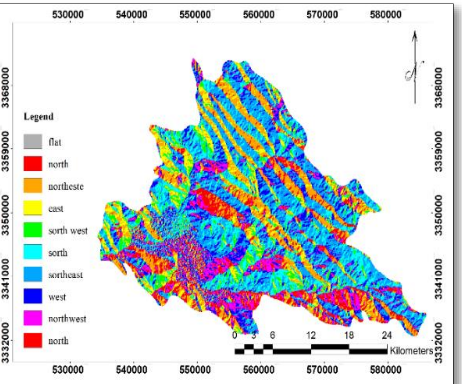


Figure 4. Slope Fahlian Basin Figure 5. Aspect Fahlian Basin

Land use and soil

Figure (6) In the northern areas, there are dense and semi-dense forests of oak, almond, and wild pistachio, which are marvelous uses of the area and these uses play an effective role to formation of the geosites. Fig :(7) Soil type contains anti-soil and rock deposits.

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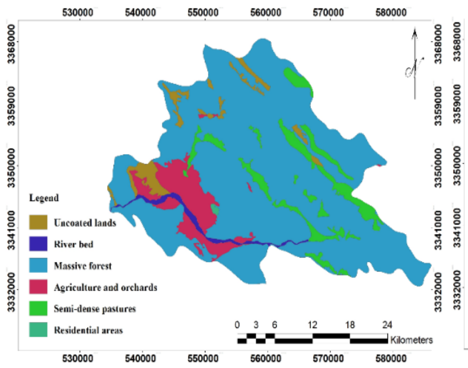


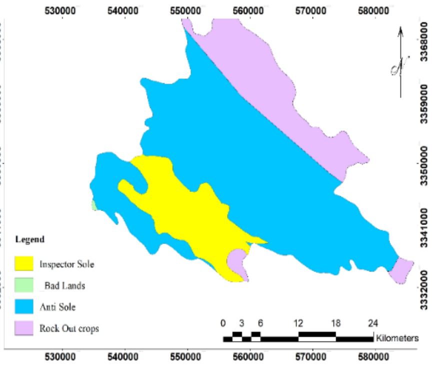
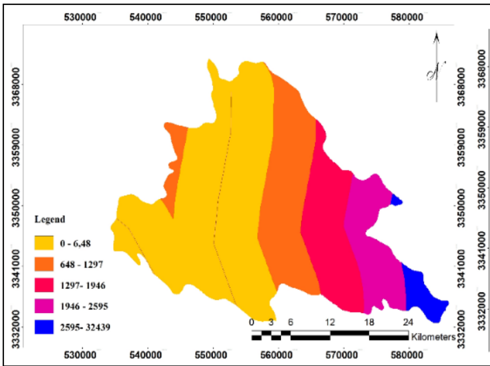


Figure 6. land use Fahlian basin

Figure 7. Soil Fahlian Basin

Distance from the fault and the channel density

The Kazeroon's fault crossed the middle areas of the plain and in the northern areas of the basin has caused formation of tectonic karst springs and also, because of presence of numerous springs, the highest channel density is in the northern areas and Asmari formations have led to formation many morphosites in in this region.



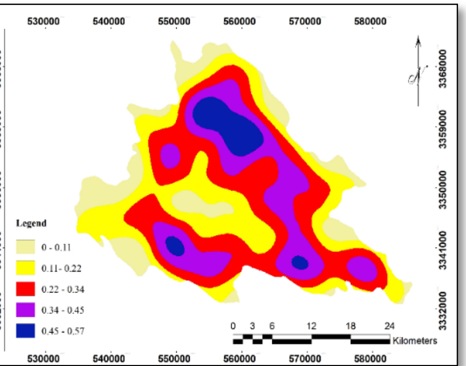


Figure 8. Layer distance from fault

Figure 9. Layer of condensation

Geomorphology is one of the most important factors in creating geodiversity in any region. Most of landforms are located in southern part of the plain. Forms such as mountain ranges, fault valleys, Tangs, multiple Grikes, springs, abundant waterfalls, orchards and oak forests as well as more moderate climate than other classes in the basin have made the region a touristic destination, which in turn has led to creation of villa houses in the area and has made the area an important hub for recreation. In this area, as we go from north of the basin to its south, variety of geomorphological forms are reduced. Since geological and geomorphological aspects are very important in Geodiversity, after investigating all the 3 classes, it was revealed that Class number 1, which is located north of the basin, has the highest geomorphological diversity, because

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from geological viewpoint, it includes resistant formations that results in a variety of shapes. Class 3 also has the highest altitude in the region. This class has resistant formations, which has led to the formation and durability of various forms and landforms. Higher altitude of the region has also provided a weather conditions for growth of trees and formation of forests. In addition, presence of many gardens have attracted many tourists to the area. On the other hand, diversity of altitude and landforms has led to an increase in roughness of terrains, which is one of the most effective factors in geodiversity calculations. Lineaments density also because its features as well as its role in creating fault fountains is important. Table 2 introduces characteristics of the separated classes in the region.

Table 2. Features of separated classes within the study scope

Class landscape	Geodiversity parameter/ description
C1	Class (C1) in located at the north and northeast of the region and it has an area of 285 square kilometers. In terms of lithology, it includes Eocene Asmari limestone, Kazhdumi, Daryan, Sarvak lime, and Cretaceous Fahlyan formations. Presence of water valleys, concentrated Tangs, waterfalls, blade constructional forms and plenty of calcareous springs are among the features of this area. The soil type is entisols and rocky. Drainage density is 0.82 m/m^2. The region slope is about 0-11 degree. The altitude is in the range of 700-1300 meters.
C2	It includes the western and northwest parts of the plain. Its area is 382 square kilometers and it includes the Bakhtiari conglomerate, which dates back to the Jurassic era. In terms of geomorphology, this class has wide alluvial fan along with aqueducts at the surface of the alluvial fan. The soil type is entisols inceptisols, and rocky areas. The drainage density is 0.85 m/m^2 and the area slope is about 11-25 degrees. The height is in the range of 1300-2000 m.
C3	This class is located in the middle of the plain and is covered with alluvial deposits. There are numerous wells in this class. The soil type is entisols, inceptisols and rocky. The drainage density is 65.1 m/m^2, which has the highest drainage density among the three classes. Kazeroon's fault crosses this class.

After preparing the layers related to 10 features of the selected classes, we tried to calculate the parameters used in calculation of geodiversity indexes for each class. Table 3 presents the results of calculating the geodiversity index in 4 selected class.

Table 3. Calculation of the Land Variation Index for 4 selected units

Land scapes	C1	C2	C3
Geology			
Litology	10	7	7
Distance from fault	14	14	14
soil			
Classifacation	2	1	2
Geomorphology			
Land form	16	10	6
slope	14	14	14
Aspect	7	7	7
Hydrology			
River Type	14	0	7
Drainage density		7	7
Collect elements	91	60	54
Geodesy index	6.59	4.3	2.9
Ln	6.7	5.39	4.37

4. Discussion

There is a significant variety of ground elements in the Fahlyan basin, including hydrological, geology, soil, and landforms conditions. Among effective factors on geodiversity, geology and geomorphology are very influential, because these two factors in the region have led to extension and formation of karst forms and abundant water resources and have added to the richness of terrestrial diversity.

Results of calculating the geodiversity index showed that class in the north of basin, compared to the other class, had the largest value, which to some extent is due to the variety of Sarvak, Darian, Fahlyan, Gadwan, Asmari, and Pabdeh Gurpi formations. This area in terms of fault density has contributed to the expansion of karst springs and due to the feature of being karst, it has the most karst forms, especially, it has the largest amount of landforms. This class has is also constituted of two soil types. In terms of geomorphology, the most diverse forms, including deep canyon valleys and straits, the diversity index in the class is twofold (4.1). In this class, the slope is very low and diversity of formations is about 10 complications. There are a variety of river types in this class. Fault density in this class includes all the classes. There is only one type of soil in this class and in terms of diversity of geomorphology, there are about 160 complications in this class. In terms of hydrology, this class has the largest points, as the main river crosses it and also the flow type is obviously shown in the form of a tree branch.

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In class 2 and 3, the geodiversity index is 4.3 and 2.9, respectively. In these two class, diversity of landforms and the drainage density have decreased and it has a poor vegetation.

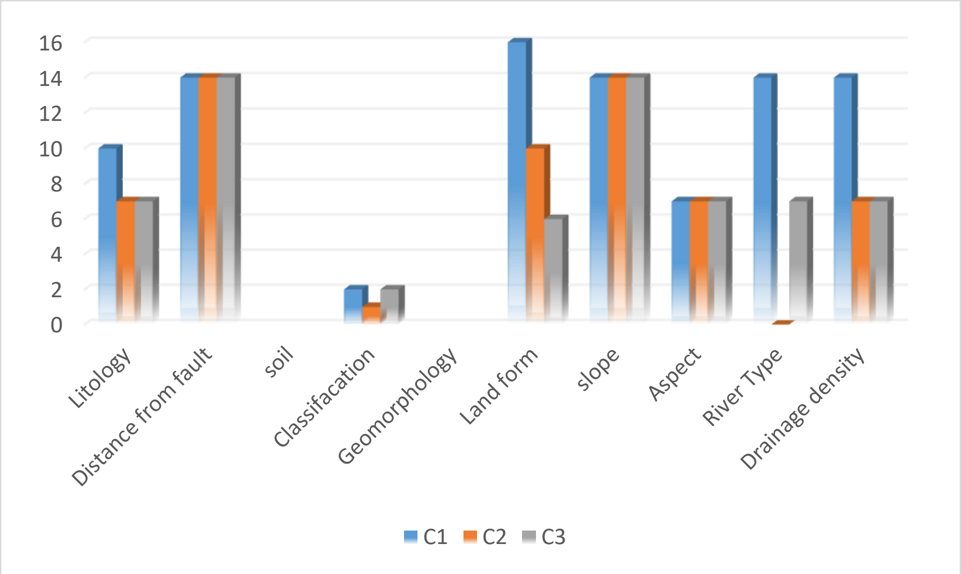

Figure 10. Geodesy chart of parameters

Figure (11) shows the final geodiversity map. This layer based on the geology layers in the region was divided. The highest value of the index was in the southern part (6.59), which is displayed in brown color and covers an area about 285 square kilometers of the basin. The geodiversity index in class 2 and 3 is 4.3 and 2.9, respectively and their area are 80.221 and 114 km^2, respectively Figure (11):

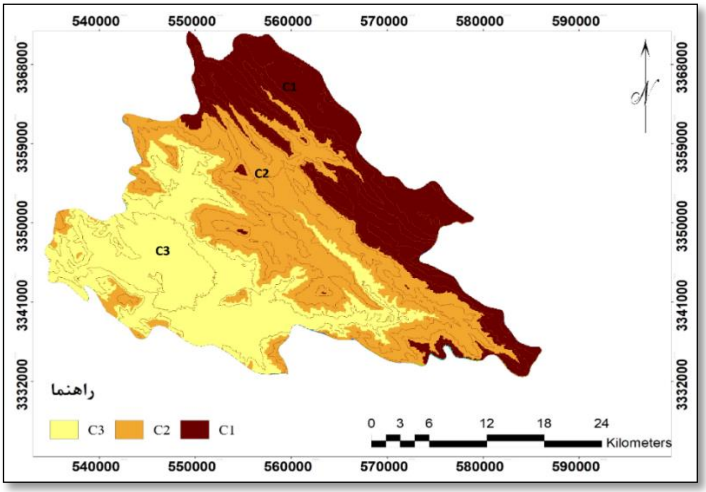

Figure 11. Geodiveresity map of selected ranges (c1-c3) in Fahliyan

Figure 12. (a): iver in the Javid (b) : Waterfall Perashcaft

5. Conclusion

Quantitative geodiversity study improves our understanding of each class and makes possible to recognize the role of various factors and degree of their importance. This research investigates geodiversity in the Fahlyan basin, located in the west of Fars province. The results of studying 3 class showed that Class 1, which is a recreational and tourism area, has the geodiversity index of 6.59 and was identified as the most diverse area in the basin. This is due to existence of diverse geomorphologies such as waterfall, valley, tang, springs, gardens and dense and semi-dense forests, which has provides conditions for development. This park is near to the main road in Shiraz-Sepidan-Yasuj road and residents in large of the provinces can go there at a reasonable time. The large

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area of the basin and rainy forest at the upstream of the area has led to abundance of sweet and savory water in the region so that throughout the year (especially in spring) from most rocky walls of the Tang, beautiful waterfalls can be seen. This water-filled area has been since ancient times a place for nomads to grow fruits and animal in the spring and summer. The walnut trees in gardens of the region have a long life. The temperature difference of this area with the Fahlyan plain in warm summer days sometimes reaches to more than ten degrees centigrade. Another advantage of the region is its paved road, as a result, it tourism capacities. However, Class 2 and 3 place in next ranks in terms of tourism. In these areas, with decrease in altitude and slope, diversity of geomorphology and geology reduces gradually. Geodiversity index in class 2 and 3 is 4.3 and 2.9, respectively.

Studying the universe in terms of geological diversity, we can have a better understanding of the natural resources of the earth. In spite of the importance of geological diversity in various dimensions, this phenomenon is threatened by human activities. Therefore, the need to protect geological diversity is felt and this is essential for the development of geotourism. Protective goals and methods need to consider different elements of geological diversity and proper planning with respect to the geosite type must be made. Management in geotourism and related recreational activities as well as in geoparks greatly depends on the amount of geological diversity.

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