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## CURRENT ACHIEVEMENTS IN GEOSITE RESEARCH

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### *Abstract*

One of the many ways of study by which geography can be useful in today's economic context is by analyzing those geographic locations that are important not only scientifically but also culturally, historically, aesthetically or economically. Called in the literature "*a bridge between science and culture*" (Reynard et al., 2018), geosites are the subject of recent but increasingly complex concerns within geosciences. Amid growing awareness of the importance of the human-environment relationship both for individuals and for society as a whole, the study of geography in recent decades has manifested a predisposition to focus on increasingly practical applications, and the scope of geographic research has broadened to actions that have in the forefront the highlighting of natural heritage, natural monuments and the need to preserve, protect and enhance the environment.

Given their diverse nature and genesis, geosites are considered to be of particular importance in understanding the Earth's natural history (Reynard 2005a), and they also play a vital role in the observation of recent and current processes in the relief, characterized by a marked dynamics in the medium or short term. For this reason, research on geosites that are subject to modification or even degradation under the influence of natural or anthropogenic causes is of particular importance and needs to be carried out periodically to analyze geomorphological processes such as landslides, mud flows or fluvial erosion. Geosites are considered to be elements of geoheritage that should be protected and preserved for future generations.

**Keywords:** geosite, geomorphosite, scientific importance, conservation, preservation

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## 1. The Historical Approach

Geosites are considered areas of great value for the environment and landscape, representing witnesses of the evolution of the planet, whose identification and knowledge provide support for territorial planning (Brancucci et al., 2002), as they enhance the connections between the physical-geographical framework of a locality and the development of human activities. The growing interest in their study, the perspectives and the proposed aims lead to the conclusion that geosites represent simultaneously a new field of scientific research, oriented towards their identification, inventory, evaluation and protection, a process of cultural integration, by obtaining an integrated cultural landscape, and an artistic suggestion endeavor, in terms of the capacity of some sites to represent inspiration for different fields of art (Panizza, Piancente, 2003).

Numerous methods for evaluating geosites have been developed in recent years by researchers all over the world, adapted either to the elements of physical-geographical identity of the regions analyzed or to the categories of values that are to be evaluated and highlighted. The aim was gradually to increase knowledge and enrich the natural heritage, to better select sites based on the criteria that make up the scientific relevance (Brilha, 2015), to eliminate the evaluator's bias, and to address the details emerging from the interpretation of the geosite evaluation results.

However, there are certain aspects that continue to be of interest in current research, such as the relationship between geoheritage and geodiversity, the development of geotourism products, or the integration of geosite studies with other scientific fields (Reynard, Coratza, 2013). The study of geosites represents a modern approach to geography, oriented towards practical applicability, sustainable development, environmental protection and conservation of the natural heritage. The purpose of geosite study is not to know the sets of values that geosites possess, but to use the knowledge gained from research in the medium and long term as a reference for the future management of geosites. Thus, the role of the evaluation itself becomes that of analysis-diagnosis, a stage that must necessarily be followed by the development of

strategies for the preserving and conservation of natural elements relevant to geosciences in terms of education and tourism.

## **2. Vulnerability and Protection of Geosites**

Research on geosites and geomorphosites to date has focused mainly on their identification, classification and assessment processes, by the development of a large number of both qualitative and quantitative methodologies for evaluating their scientific and additional values (Coratza, Giusti, 2005; Bruschi, Cendrero, 2005; Reynard, 2006; 2009), their educational potential (Reynard et al, 2018; Pereira et al., 2019; Martínez-Graña, et al. 2021; Maxwell, Joseli, 2021) and tourism potential (Brilha, 2016; Forleo et al., 2017; Bouzekraoui et al., 2019; Alexandrowicz, Alexandrowicz, 2022; Golfinopoulos et al., 2022). On the other hand, a less researched area is the issue of vulnerability of geosites, the knowledge of the risk to degradation that they imply. The need for such research is imposed by its contribution to geosite management and conservation processes, as natural heritage is itself under constant pressure imposed by natural and anthropogenic processes and factors (Selmi et al., 2022).

As geosite inventory and assessment methods have diversified, providing researchers with objective views, both quantitative and qualitative, the understanding of the scientific value has generated new challenges, this time oriented towards answering concerns aimed at the management of inventoried and assessed features. Once a geosite has been identified and then evaluated, it requires certain legal protection measures and the implementation of strategies aimed at preserving or even increasing its value (Henriques, 2015). Thus, the post-assessment stage has acquired an identity (but also an increasingly pronounced role in the study of geosites), which brings together all the methodological, material and decision-making elements that impose an active role from the moment the assessment of the scientific value and additional values of the geosite is completed. New studies may be included in this stage and new qualitative or quantitative methods or sustainable development strategies oriented towards the protection and use of geosites may be applied. Special attention should be paid to the fact that, like methods

aimed at assessing sets of values, approaches aimed at the protection or valorization of a geosite or geomorphosite cannot be applied according to general criteria, as it is particularly important at this stage to analyze the regional framework, the involvement of social, economic, cultural, political and other factors with local specificity. These form an “external environment” which plays a vital role, as understanding them and adopting appropriate strategies in line with the rigors imposed by them is a requirement for effective geosite management.

Geosites are constantly subject to the actions of environmental factors as well as anthropogenic factors, which can influence geosite dynamics: in some cases geomorphological processes are accentuated or slowed down, but in other cases the very integrity of geosites may be threatened. Thus, geosites are *vulnerable* to both anthropogenic impacts and the effects of natural processes on landform evolution (Reynard, 2009).

In a broad sense, the term *vulnerability* refers to the degree of loss that can result from the potential of an event to cause casualties and property damage (Grecu, 2016), or to the effects of disasters occurring at certain times, such as the vulnerability of a grassland to flooding when peak flows occur in the spring months (Ielenicz et al., 2013). In the case of a geosite, vulnerability is the degree of actual degradation that can occur within it from the potential of any event to cause damage. Depending on its typology, size, lithological composition, dynamism, the geomorphological processes involved, its geographical location and its vicinity, a geosite may have different degrees of natural vulnerability, which is why a standard, generally accepted methodology compatible with any geosite cannot be drafted. Also, vulnerability in relation to the potential anthropogenic factor can only be analyzed separately, as the interaction between geosite and human is specific to each region and to each type of geosite.

International literature proposes several models for assessing the risk of degradation, vulnerability of geosites and geomorphosites (Fuertez-Gutierrez et al., 2010; Lima et al., 2010; Brilha, 2016; Selmi et al., 2022), as essential steps in any geoconservation and management strategy for geological heritage features. The natural processes to which a geosite may show vulnerability are on the one hand those related to the natural

evolution of the landform (self-destruction), and on the other hand those acting on the geosite from outside (climate change, earthquakes, landslides, floods), while anthropogenic threats are associated with tourism activity, infrastructure development, agricultural activities, vandalism and urbanization (Reynard, 2009). The geosite is not only vulnerable to the generating hazard (to a specific hazard), but also to associated hazards, as it represents a sequence of temporary dynamic equilibrium within an evolutionary system, and the manifestation of a hazard is a phenomenon likely to alter the dynamic equilibrium and create visible effects on the environment and society (Grecu, 2017).

The risk elements of a geosite can vary substantially, depending on its characteristics and the typology of the damaging phenomenon, from minor components and surfaces subject to erosion, to dynamic components in transition. A geosite developed on a slope will be permanently influenced by runoff processes, landslides occurring and/or the amount of rainfalls corresponding to the morphoclimatic region concerned. Geosites located in high mountain regions or on surfaces lacking vegetation are subject to the shaping action of external agents. The development of a geosite within a river bed will impose a high dynamics, based on particularly active fluvial processes, but also an increased vulnerability to hydrological risk phenomena, such as floods, and even the risk of total degradation. In all cases, risk elements will be significantly reduced if the geosite is already known and has been subject to the assessment process and subsequently protected.

In the process of identifying the vulnerability of a geosite, several characteristics that influence its response to natural or anthropogenic hazards are taken into account (Grecu, 2017): degree of resistance to environmental factors, response to hydro-meteorological input, capacity to correct the effects of a hazard in order to return to the initial equilibrium after the occurrence of a hazard (resilience), capacity to adapt to environmental changes, temporal and spatial dimensions. As geosites can present a real risk of being totally or partially damaged both by external agents and geomorphological processes and by anthropogenic intervention specific to the development of educational and tourist activities, methods of assessing the risk of degradation may involve indicators such as: damage to geological elements, proximity to areas

with potential hazard, legal protection, accessibility or population density in the area (Brilha, 2016). Following the analysis of the risk elements to which a geosite is subject, it will be possible to determine its protection policies aimed at mitigating the risk, i.e. the losses of any kind that a geosite may suffer as a result of a potentially destructive phenomenon.

### **3. Tourism and Educational Exploitation of Geosites**

In the literature, approaches to *tourism relevance* focus on the connections between the tourism value of geosites and the benefits that this activity can bring to the localities in which they are located. Among the benefits of tourism valorization are supporting local development strategies designed on the basis of demographic, economic and tourism analyses (Forello et al., 2017) or starting from the importance of geotourism routes as tools in promoting geotourism and geoeducation (Bouzekraoui et al., 2019). Their promotion and rational management create opportunities for sustainable development and contribute to the emergence of quality tourist destinations by nature protection and education.

It is thus noted the need for the implementation of legislative frameworks to ensure proper management of geological heritage, by preservation policies that contribute to the promotion of a harmonious relationship between society and the environment (Zafeiropoulos et al., 2021). At the same time, the tourism exploitation of some geosites can significantly contribute to the improvement or removal of economic or social problems faced by some local communities (Reynard et al., 2015), as it involves the generation of jobs, thus stimulating the tourism industry and supporting the principles of sustainable development.

The issue of the educational importance of geosites is the subject of recent studies proposing the use of various teaching methods and techniques, for example courses, platforms (Pereira et al., 2019) or panels, aimed at disseminating knowledge about geomorphological heritage to a target audience (Reynard et al., 2018).

The generation of high-performance educational resources, designed based on new technologies, can also contribute to highlighting and

promoting the geological heritage of a region, as they form a familiar and efficient environment for the learning process. Examples in this sense can be: virtual geological itineraries, multimedia contents and elements of augmented reality (Martínez-Graña, et al 2021). Rapid technological development has enabled changes in the way tourism potential is approached, and the use of digital tools in the study of geosites can ensure the extension of their landscape value. At the same time, interactive cartographic supports and virtual routes allow a good visualization and even understanding of the landscapes associated with certain geosites and provides a modern and attractive support for educational use (Maxwell, Joselli, 2021).

Another example of a stimulating element for the development of local communities through education and with respect to sustainable principles is geoparks. These involve in situ research experiences and thus convey a range of knowledge about the studied territory and its sustainability, promoting it as a pedagogical resource (Fernandes, 2021). Such a vision has its origins at the end of the last century, when UNESCO's Division of Earth Sciences set up the Geopark Programme, aiming to highlight and exploit the educational potential of heritage features, as they represent real natural laboratories for geoscience and education (Khoshraftar, 2013). Geopark is a term that refers to facilities of geosites and geomorphosites that are promoted for tourism interest, through an approach that targets the capacity of a region to host educational activities to popularize the values held (ProGeo, 2011). Geological features, current geomorphological processes, soil characteristics and genesis, biodiversity elements and any other relevant feature that can make the region scientifically and aesthetically unique are taken into account. The aim is to ensure a healthy natural environment, to popularize geoscience among the general public (tourists) and at the same time to contribute to the development of local communities by geotourism (Khoshraftar, 2013).

Even though geodiversity as a whole is considered the main resource for geotourism and geoeducational activities, a specific position is occupied by geomorphological features, and international research also emphasizes the importance of active geomorphological processes,

which, despite being classified as hazards, can serve educational and tourism purposes (Kubalíková et al., 2021).

All the efforts of management, planning, protection, knowledge of the risks of degradation, as well as the legal decisions adopted in support of their conservation, to ensure the preservation of the integrity, representativeness and elements that make the geosite rare, and for an appropriate valorization, are the direct result of the application of analysis models such as those presented above, adapted to the local specificity of each geosite. These concerns have been a defining element for the research work and for highlighting the scientific importance of geosites. Nature conservation concerns are a relatively recent discipline, whose evolution has been the result of a long series of challenges and efforts, and the diversification of geosite study modalities is responsible for the individuation of new fields and approaches.

#### **4. Recent Approaches to Geosites in Romania**

Approaches to the process of inventorying and evaluating geosites in the country have intensified in the last decade, following the research directions and analysis methods proposed by the international literature. The researches carried out indicate an effort to highlight the natural potential of Romania, the practical applicability of the study of geosites in our country and their scientific, cultural, economic, ecological and touristic importance.

The Romanian literature includes mainly regional studies: evaluation of geomorphosites within the Viștea glacial valley, Făgăraș Mountains (Comănescu L., et al., 2011), evaluation of geomorphosites within the Ponoare protected area (Comănescu, et al., 2012), evaluation of geomorphosites within the Bucegi Mountains (Comănescu et al., 2013), inventory and quantitative evaluation of geosites within the Danube Defile (Grecu, Iosif, 2014a), inventory of geosites in the Dobrogea Plateau (Rădulescu, Grecu, 2018a), evaluation of geomorphosites developed on glacial and periglacial landforms in the Southern Carpathians highlighting geomorphological diversity (Comănescu, Nedelea, 2017), paleontological importance of the Canaralele geosite in Hârșova Port (Dumitraș et al., 2019), the preliminary assessment of the Hârșova



Abator Quarry in terms of scientific importance and ecotourism potential (Macovei et al, 2020), the analysis of the sustainability of the relief at geomorphosites from a tourism point of view and the analysis of the potential and use of geomorphosites in the Baiului Mountains (Barbălată, Comănescu, 2021), the inventory of geosites, geomorphosites and geodiversity and biodiversity elements within the Putna River Basin (Necula et al., 2022), the analysis of the geoturistic potential of the salt areas in Buzau County by the quantitative evaluation of the scientific, educational, touristic and degradation risk value of some geosites (Toma et al., 2022).

Recent research has been oriented towards the profound interdisciplinary character of geosites, especially towards their geoturistic potential. Numerous regions of Romania have been the subject of quantitative research highlighting the geomorphosites' geoturistic value in order to rethink protection measures and tourism promotion, such as the Danube Defile (Greco, Iosif, 2014b), the Apuseni Mountains (Cocean, Cocean, 2016), Bucharest Municipality (Comănescu et al., 2017), Dobrogei Plateau (Rădulescu, Greco, 2018b), Toplița (Niță, 2018), Putna-Vrancea Natural Park (Tufănoiu et al., 2020) or the Metaliferi Mountains (Milu, 2021).

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