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Review

Geosite Assessment and Communication: A Review

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Abstract: This work is aimed at reviewing the current state of the art in geosite selection, assessment, and communication. We first highlight the main papers that have defined paramount concepts such as geodiversity, geoheritage, and geosites. We then delve into the theoretical principles and guidelines that have been proposed over the last twenty years by researchers who have thoroughly illustrated how to individuate and assess geosites. In doing so, we illustrate notable field examples of applications of qualitative and quantitative assessments of geosites in places such as Serbia, India, Iceland, Ecuador, Sardinia (Italy), Egypt, Tasmania (Australia), and Brazil. The third part of this work is dedicated to illustrating a list (by no means exhaustive) of works that have tried to come up with innovative tools, strategies, and solutions to promote and communicate geosites. From our work, it appears that geosites can be extremely effective as fully fledged outreach tools capable of bridging the gap between Earth science and the lay public.

Keywords: geosites; geoheritage; values; scientific; educational

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1. Introduction

1.1. Geodiversity, Geoheritage, Geosites

Natural diversity can be subdivided into biodiversity and geodiversity [1]. Geodiversity expresses a variety of geological (rocks, minerals, fossils, sediments), geomorphological, hydrogeological, volcanic, tectonic, stratigraphic, sedimentary, and paleogeographic features that represent the natural context on which anthropic activities take place [2–5]. Another key concept is geoheritage, which needs to be evaluated [6], managed [7], subjected to conservation [8–14], valorized through geoparks [15–24], and be the focus of geotourism [25–35], geoscience museums [36–39], and mapping [40,41]. Preserving geoheritage means safeguarding the natural diversity of major geomorphological and geological elements, i.e., geoheritage sites, also known as geosites. These are natural features [1] which represent the geological heritage of a territory [40,42] and are marked by a number of distinctive values, as illustrated in the next chapter. They are not always natural features, but they can be quarries, spoil tips, road cuttings, and even museum collections. Geosites can also be defined [43,44] as "places where geological objects or fragments of the geological environment are exposed on the land surface, and thus are accessible for visits and studies". A step forward has been taken by Gioncada et al. [45], who have underscored that "the definition of a geosite should be interpreted as an outstanding outreach activity based on a deep knowledge of the general and local geological significance of the proposed site". Geosites can be represented by geomorphological features and processes, which can be part of geomorphodiversity [46] and are called geomorphosites [25,47]. Geosites can be related to a great deal of topics within the Earth science field. Thus, there are paleontologic [48], mineralogic [49], petrologic, volcanic [50–52], tectonic, igneous, mining [45], hydrogeologic, sedimentary, stratigraphic, and paleogeographic geosites. A special mention to the latter is needed, given their complexity. In fact, Bruno et al. [53], describe paleogeographic geosites as "geological heritage sites that represent paleoenvironments in general or highlight particular paleoenvironmental features, which are of special interest for science, education, or tourism/recreation". Geosites can be as small as a single outcrop or big and complex, such as the unique Granite Gorge in Mountainous Adygeya, Russia [54]. They can be classified in five typological categories: point, section, area, complex area, and viewpoint, as proposed by Fuertes-Gutiérrez & Fernández-Martínez [55]. On account of their importance, they may be of local, regional, national, or global relevance [56]. Geosites may also be differentiated based on their spatial appearance: circumscribed sites such as outcrops, linear features such as faults, as well as aerially extended features such as peaks.

1.2. Visual Examples of Geosites and a New Type of Geosite

In Figure 1a, we show a portion of the Mt. Etna volcano, a huge, complex geosite, composed of a great number of smaller volcanic geosites, the protection of which has been made possible by the institution of the Parco dell'Etna Geopark [57]. In Figure 1b, we display an example of a major tectonic geosite: the Kura foreland basin in the foreground, with the Kura fold-thrust belt [58,59] in the background. The two can be treated as one geosite because they are part of a unique tectonic process, i.e., the propagation of the Greater Caucasus towards its foreland basin, through an actively southward-propagating fold-thrust belt, whose basal thrust is seen at the transition between the plains and the mountains in the background. Figure 1c shows a wonderful example of a geomorphosite, the Godafoss waterfall in northeastern Iceland.

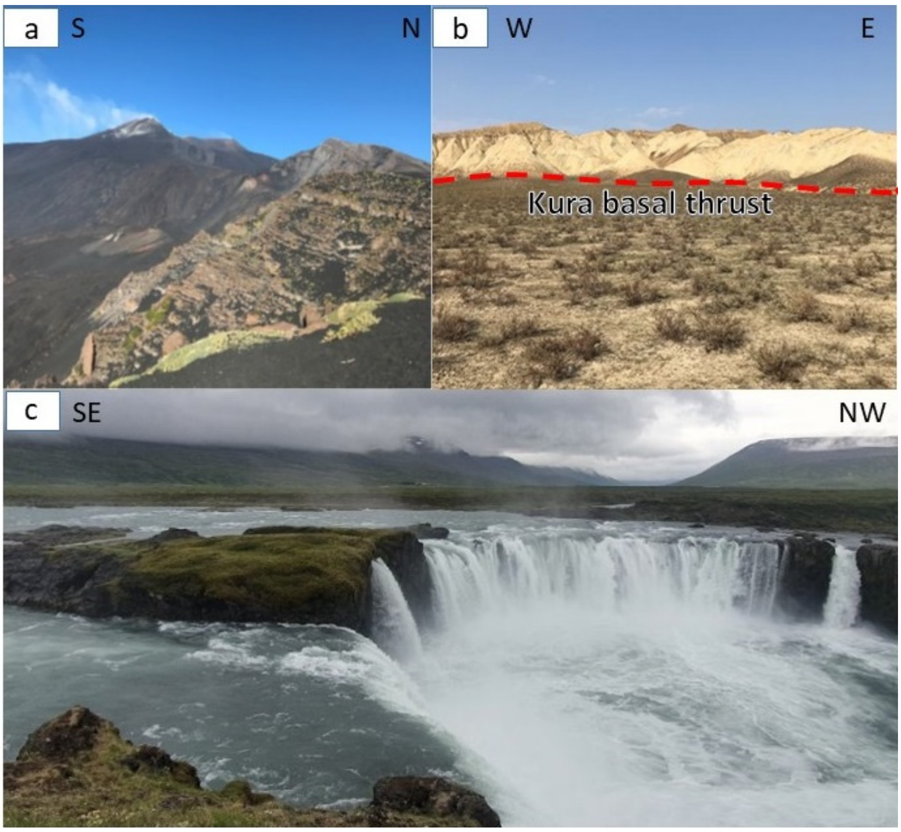

Figure 1. (**a**) In the foreground, the Bove Valley, in the background, the southeastern crater of Mt. Etna volcano. Photograph by F. Pasquaré Mariotto. (**b**) In the background, the Kura fold-thrust belt near its southern section, transitioning into the Kura foreland basin (in the foreground), Greater Caucasus, Azerbaijan. Photograph by F. Pasquaré Mariotto. (**c**) A very good example of a geomorphosite is the outstanding Godafoss waterfall in northeastern Iceland. Photograph by Paolo Oppizzi.

Among a possible new type of geosite, it is worth mentioning gravity-related landforms. An example of such gravity-related geosites is represented by deep-seated gravitational slope deformations, which are widespread in mountain ranges such as the Alps [60] and which are discussed among the examples of geosite communication provided in the third section of this work [61].

In the following chapters, we will focus on a number of milestone papers dealing with the selection and assessment of geosites, carried out through the application of a set of values. Subsequently, we will describe experiences of geosite promotion and communication. We wish to stress that our work is not comparable to bibliometric analyses that, according to Herrera-Franco et al. [62], contribute to reconstructing the evolution of an academic topic, such as geoheritage, from the beginning to future prospects. We have chosen to perform a selection of the numerous works on this topic, which we regard as most representative and challenging.

2. Geosite Selection and Assessment

2.1. Geosite Selection

First of all, it is worth pointing out that selecting a geosite for geoconservation implies defining its importance based on objective criteria and not on someone's subjective judgement. So, before delving into geosite assessment, it is worth mentioning a set of works that have illustrated the methodology that needs to be used to select localities that ought to be recognized as geosites and geomorphosites and thus should be conserved, also for geotourism purposes (e.g., [63–68]). In this regard, it is particularly worth mentioning the milestone paper by Wimbledon et al. [65], which described in detail the comprehensive site selection program known as the Geological Conservation Review, undertaken in Britain from 1977 to 1991. The Review formed a vital foundation for successive Earth science conservation efforts. Its product was a complete network of scientifically justified sites for conservation. In the following years, a key initiative from the International Union of Geological Science (IUGS) was the project named GEOSITES, inaugurated in 1995 with the aim to identify meaningful geological and geomorphological sites at the worldwide and regional level [69,70].

Now, starting with some examples of selected geosites, we highlight the work by Migòn et al. [71], who described the granite geomorphological heritage of the Waldviertel region in Lower Austria, home to a great deal of geomorphosites represented by residual landforms, tors, and boulders, which can be observed in various sizes and shapes. In particular, their shapes can be very distinctive and uncommon, thus capable of capturing the interest of the lay people. On the other hand, Gnezdilova et al. [72] selected a number of geosites and highlighted their evolution in geological time, describing a sequence of ancient environments and ecosystems which may be very interesting for the public, also in order to increase awareness of past and future climate change. As illustrated by Archer [73], Hay [74], and Bottjer [75], extreme climate change comparable to the one we are experiencing today, as well as its impacts on the environment, can be observed in our planet's geological history. Therefore, paleogeographic geosites could be used as educational tools, unveiling past and current climate change, and prompting mitigation and adaptation strategies.

2.2. Geosite Assessment

A major effort has been made in the recent past, by several authors [1,76–80], to come up with approaches aimed at performing the assessment of geosites, using a range of criteria. Most assessment efforts use the scientific value [81], which may be subdivided into four subcriteria: representativeness, integrity, rarity [82–84], and also the degree of scientific knowledge about the geosite, attested by the number and quality of published scientific studies focused on the geosite [1]. Representativeness regards how exemplary a geosite is in terms of the geological processes that can be seen there. Rarity pertains to the uncommonness of the geosite if compared to geosites of the same typology at the global level, whereas integrity represents the degree to which the geosite is preserved [83].

In addition to the scientific one, other values, referred to as "additional" [85,86], can be identified and assessed: cultural, ecologic, economic, aesthetic, and educational. The cultural value consists of four subcriteria: historical, artistic, religious, and literary [83]. Among the above, it is particularly worth mentioning the aesthetic value [87] and the educational value, the latter defined [1] as the combination of didactic relevance (how easily a geosite's characteristics or processes might be understood by the lay people), safety, accessibility, and possible exploitation of the geosite for educational activities (georoutes and guided tours). We hereunder provide an overview of a number of papers that dealt with geosites, described them, and subsequently attempted to assess their quality on the basis of most (or some) of the above criteria and values. Regarding geomorphosite assessment, many works in the last two decades have taken on this task [31,47,83,85,88–90].

We begin our overview with the work by Pasquaré Mariotto et al. [63], who focused on two key areas of Iceland, namely the Snaefellsnes Peninsula in the western part of the island, and the North Volcanic Zone (NVZ), a tectonically active area in northern Iceland. In regard to the first area, the authors identified two peaks (Figure 2): the 1446-m-high Snæfellsjökull stratovolcano and Kirkjufell, or "Church Mountain".

Figure 2. (**a**) The majestic figure of ice-capped Snæfellsjökull volcano; (**b**) Kirkjufell, an iconic peak that is the most photographed natural feature in Iceland. Photographs by Fabio L. Bonali.

Regarding the first, the authors were able to recognize virtually all the values that concur to assess the quality of a geosite, including the literary one, as Snæfellsjökull is featured in the well-known science-fiction novel by Jules Verne, Journey to the Center of the Earth (1864). The famous stratovolcano also has a high educational value: in fact, it is easily accessible and is situated within the Snæfellsjökull National Park (founded in 2001), where guided tours are carried out on a regular basis. As pertains to Kirkjufell, although not as representative of most values that define a geosite, it certainly has a major educational value. In fact, all subcriteria can be mentioned and assessed: the peak is very easily accessible, the processes that led to its formation (glacial erosion of a pile of ancient basalts) can be easily understood by the lay people, and, finally, guided tours to the base of the peak are conducted regularly.

A very good example of geosite assessment is the one performed by Carriòn Mero et al. [91], whose work has been aimed at evaluating the most interesting geosites in the Chimborazo province (Ecuador) and putting forth options for the development of geotourism in the study area. The authors' methodological approach was based on: (i) a preliminary inventory of geosites that resulted in 20 selected geosites; (ii) a semi-quantitative geosite assessment and proposal of travel itineraries for geotourism purposes; and (iii) the application of the strengths, weaknesses, opportunities, and threats (SWOT) matrix to the development of geotourism strategies, keeping into account the principles and values of sustainability. The authors' assessment suggested that 25% of the 20 evaluated geosites are very highly interesting and 75% are highly interesting. The top three geosites assessed by the authors are the Chimborazo volcano, also known as "Earth's Closest Point to the Sun", the Pallatanga fault, active for the last 600 ka [92], and the geosite called Cacha Community, which features rustic huts and circular museums as part of the Pucaratambo tourist center.

The Geosite Assessment Model (GAM) methodology was first applied by Vujičić et al. [93], when dealing with the assessment of geosites in the Fruska Gora Mountain, located at the confluence of the Danube and Sava Rivers, in the Autonomous Province of Vojvodina, northern Serbia. For the purpose of their research, the authors used the inventory of geosites at Fruska Gora Mountain that had been assembled by Markovic et al. [94], who had come up with 14 geosites, evaluated in terms of their scientific, educational, and aesthetic values, current condition, and accessibility. The result of the further assessment by Vujičić et al. [93] suggests that the Fruska Gora Mountain geosites have a good number of main values, but low additional values; the authors conclude that they could be considered only as potential tourist attractions in terms of their scientific/educational value and aesthetic attractiveness.

According to Tomic and Božic [95], the Lazar Canyon area (eastern Serbia) shows a number of geosites of remarkable scientific value and high geotourism potential. The authors selected three geosites in particular: the Lazar Canyon, the Lazar Cave, and the Vernjikica Cave. For the assessment of the above geosites, they applied a slightly modified version of the GAM methodology, which they called M-GAM. This methodology entails the contribution of tourists, whose opinions, according to the authors, should lead to more objective and accurate results than those obtained by experts only.

Saurabh et al. [96] focused on the Mehrangarh ridge (MGR) of Jodhpur City, situated in northwestern India, whose landscape developed between 750 to about 540 million years ago and spans two major periods (Cryogenian and Ediacaran) of the Earth's history. The authors, based on a qualitative assessment, identified 12 geosites that might be helpful in fostering the development of geotourism in India, a country which, according to the authors, has yet to establish its first geopark.

Fancello et al. [97] have focused their work on a stretch of coastline along the south-western side of the Gulf of Cagliari, Sardinia, Italy. The authors selected seven geosites and assessed them on the basis of at least three of the following parameters: scientific value, educational value, aesthetic value, accessibility of the sites, and proximity to touristic facilities. This work is particularly valuable as it considers a region (Sardinia) whose geological significance and interest is well known to geologists but not to the hundreds of thousands of tourists that flock to the island every summer.

Sallam et al. [98] have centered their analysis on the Faiyum Oasis in the Western Desert of Egypt, renowned for its paleontological content, but whose geological heritage has not yet been studied in detail. By means of a careful assessment of the several geological features in the Oasis, the authors have performed an assessment that, together with the above-mentioned values, considers also the relative abundance and intrinsic diversity of the studied geosites. Their assessment made it possible to select 10 geosites that may become the main attraction of a future geopark situated in the Oasis.

Another example of geosite evaluation is contained in a work by Marescotti et al. [99], who have performed the qualitative and quantitative assessment of 10 geosites in the

Beigua UNESCO Global Geopark (Liguria, Italy), which features 54 sites known for their significant geological peculiarities. Among the 54 sites, the authors selected five of the twelve geosites officially listed in the Italian National Inventory of geosites by ISPRA [100] and five geosites chosen as representative of different geological features and processes, as well as relevant educational activities conducted in the park during the past decade. For each of the selected sites, the authors carried out a qualitative and quantitative assessment by applying the criteria and methodology put forth by Brilha [1]. Among the great deal of outcomes of this milestone study, we chose to mention the fact that the quantitative assessment of the ten selected sites enabled us to observe a much higher scientific value of the geosites featured in the Italian inventory by ISPRA [100] than the other geosites (apart from one exception). This is consistent with the fact that geosites included in the Italian inventory must have, as a primary condition, a recognized scientific value in terms of representativeness, rarity, integrity, and scientific knowledge.

Visnic et al. [101] proposed a list of loess geosites on the Srem Loess Plateau, which may turn into major elements of Serbia's geotourism potential. In doing so, the authors make use of the Geosite Assessment Model (GAM) proposed by Vujičić et al. [93]. Ten geosites have been assessed by way of the GAM model: half of them received high-level scores in terms of the criteria that can foster the development of geotourism in the area.

Franceschelli et al. [49] have concentrated on a single geosite, which could be called a "petrologic/mineralogic geosite": in the territory near Tamarispa village (northeast Sardinia); they describe in detail stunning wollastonite–garnet–diopside-bearing marbles and illustrate mineralogical peculiarities such as the size of a rare garnet mineralization, represented by giant poikiloblastic garnet crystals up to 20 cm in diameter. The assessment of the geosite results in two main conclusions: it has a high scientific value (e.g., rarity of the garnets and representativeness of the petrological processes) and a major educational value, also being easily accessible for tourists.

The work by Carrion-Mero et al. [102] illustrates a qualitative and quantitative assessment of the "El Sexmo" Tourist Mine in Zaruma, southwestern Ecuador. The most challenging assessment was the quantitative one, made possible by the application of both the GAM methodology, proposed for the first time by Vujičić et al. [93], and the one elaborated later by Brilha [1]. The authors highlight the exceptionality of the Mine and claim that, thanks to their study and their proposals for protection and improvement, the number of visitors could increase from 9000 to approximately 12,000 people per year. This, in turn, would boost geotourism while at the same time pursue the goals of sustainable development of the area.

The work by Ruban et al. [103] centers on The Golden Triangle economic zone of eastern Egypt, between the Nile Valley and the Red Sea coast. This is a historical mining area rich in geological features. Field investigations and literature analysis have enabled the authors to identify eight notable geological sites, assessed as geosites based on the following criteria: accessibility, vulnerability, scientific value, educational value, touristic importance, and aesthetic attractiveness.

Wellington Park, located in southeastern Tasmania, is the location of research by Williams and McHenry [104], who assessed the geosites in the Park mainly according to the assessment methodology by Brilha [1]. They also made extensive use of Geographic Information Technology (GIT) tools while carrying out a revised inventory of the Park. Regarding the possible degradation, most geosites in Wellington Park were at low (59%) to moderate (37%) risk. In fact, many potential geosites were situated more than 1 km away from a degradation source, had reasonable legal protection, and had difficult accessibility.

A total of 25 paleontological geosites were analyzed by dos Santos et al. [105] in the Sousa sedimentary basin in northeast Brazil. The authors compiled an inventory and assessment of the scientific, educational, and touristic values, together with the vulnerability of the geosites. They concluded that the fossiliferous geosites of the Sousa basin have low scientific and touristic values, moderate educational value, and are subject to a high degree of vulnerability. In fact, the fossiliferous areas are affected by strong natural and anthropic threats and are at high risk of degradation. Based on their assessment, the authors do not judge favorably the possibility to develop a geopark in the Sousa basin.

Other interesting geosite assessment efforts are the ones performed by Tomić and Božić [95], Štrba [106], Kubalíková and Kirchner [107], Suzuki and Takagi [108], and Raeisi et al. [109]. All the above works have one point in common, i.e., to have performed the assessment of geosites and geomorphosites for geotourism development purposes.

3. Geosite Promotion and Communication

Once a geosite or a morphogeosite has been selected and assessed, it has to become subject to promotion and communication. In this chapter, we provide a few examples of this kind of crucial activity, without which geosites would remain something accessible only to Earth scientists and not to the lay public. We are aware that the list of examples detailed hereunder is by no means complete and exhaustive, and that there are other research groups that have been actively working in the field of geoheritage management, promotion, and communication, using cutting-edge technologies such as 3D visualization, web mapping, unmanned aerial vehicles, augmented reality, and virtual reality (e.g., [110–116]).

We introduce the first of the papers about which we are going to provide some brief details, by examining the work of Gioncada et al. [45], who have described the volcanic and mining geoheritage of San Pietro Island, Sardinia, Italy. The island belongs to the Sulcis Volcanic Province (SVP) at the southwestern end of Sardinia; according to previous work [117,118], the SVP is composed of eleven major ignimbrite sheets, from trachytes to rhyolites in composition. Gioncada et al. [45] have selected three geo-volcanological features: stunning megafolding structures of rhyolitic lava flows named comendites, some unique degassing features in ignimbrites, and beautiful manganese mineralizations with the associated mining heritage. The identified folds are extremely rare in that they affect the whole of the lava flows and have been described and discussed for the first time by Cioni and Funedda [119]. Another spectacular feature on the island is represented by particular cavities in welded ignimbritic deposits, due to particular degassing phenomena [120]. The third feature upon which the authors have concentrated their attention is typical of fossil volcanic environments, places where the deposition of economically valuable minerals often takes place. This is due to the action of hydrothermal fluids that move and concentrate ore metals [121]. At San Pietro, the spectacular features shown by the authors and deemed valuable in terms of geosite selection are peculiar black veins and nodules of Mn-oxide minerals, hosted in the lava and ignimbrite units. Four geosites are proposed by the authors, who then propose a great deal of activities that might serve to valorize the selected geosites on the island. We hereby provide the most meaningful ones: the revision and enhancement of geocommunication boards along the most frequented touristic trails; the realization of field guides for students and researchers as well as other divulgative materials (i.e., booklets) for the general public; and the proposal to renovate some of the old mining buildings, which might host small visitor centers to enable the tourists to obtain information about the mining history of the area.

Moving from one island to another, we examine the work by Antoniou et al. [122] in Santorini, Greece, one of the best-known volcanic localities in the world, as well as one of the most touristic. The key locality selected as a geosite is Metaxa Mine in the southwestern part of the Santorini Volcanic Complex. Here, mining of pumice was carried out until 1984. As the mine is nowadays abandoned (Figure 3), this provides a unique opportunity to make it a real open-air geological museum, useful for studying volcanic deposits of the most devastating eruption that took place on the island in the last 10,000 years (the so-called Minoan eruption), one of the largest volcanic explosive events on Earth [123–125]. Of particular interest and suitability for geosite communication is the Late Bronze Age (LBA) section, situated in the westernmost sector of the mine.

Figure 3. An overview of the outstanding pumice cliffs of Metaxa Mine, Santorini, Greece. UAV-captured photograph by Fabio Bonali. See man for scale on the left-hand side of the image.

The mine itself is distinguished by the presence of 15-m-high, extremely steep cliffs, therefore unsuitable for fieldwork and touristic purposes, and also subject to debris flows and rock falls that prevent movement next to the outcrops to appreciate the succession of the deposits erupted during the Minoan eruption. However, the Metaxa Mine has a potentially high educational value, providing the lay public with an invaluable chance to learn about the succession of volcanic events that led to the deposition of the LBA section and other deposits seen in the mine. Therefore, the authors have decided to overcome these limitations by means of immersive virtual reality (IVR) and non-immersive VR techniques, thanks to which this outstanding site has been made available worldwide, both for scientific and educational purposes. The authors shared online the whole 3D model of the Metaxa Mine, accessible at https://geovires.unimib.it/geosites/geosite_005/ (accessed on 18 November 2022), where all relevant features are highlighted, as well as the 3D model of the famous LBA section (https://geovires.unimib.it/geovolc/geovolc_006/, accessed on 18 November 2022).

Pasquaré Mariotto and Bonali [126] have showcased the use of virtual outcrops, or "virtual geosites", to communicate to the lay public the peculiar processes that occur in the shallow crust and result in geological features known as "subvolcanic bodies". These are outstanding in Iceland, where extensive glacial erosion has exposed the plumbing systems of ancient volcanoes. Subvolcanic bodies from Iceland have been studied in detail (e.g., [127–129]) but they are generally poorly known outside the small number of specialists that focus their research on these magmatic features. However, it is absolutely worth highlighting an outstanding work [130] that has been aimed at guiding readers through the "glorious geology of Iceland" and has also focused on subvolcanic bodies. In addition, Pasquaré Mariotto and Bonali [126] have chosen to assess a few subvolcanic bodies from eastern Iceland and subsequently to suggest a way to popularize them as geosites, possibly worthy of geotourism development. In doing so, they have shown a methodology to make these Icelandic geosites available to the general public, thanks to breakthrough methods involving the use of drones and structure from motion (SfM) techniques. They have thoroughly described five virtual geosites (VGs) in a "virtual geotour mode" and made them available online, so as to enable potential viewers to access them and gain a better knowledge of subvolcanic bodies and processes. An example of a VG can be accessed at https://geovires.unimib.it/shallow-magma-bodies/smb_002/ (accessed on 21 November 2022).

Forno et al. [61] have taken on the task of looking into the topic of complex geosites, which are major elements of the geoheritage of a region, but whose geoconservation and promotion may be difficult to accomplish. The area the authors have focused on is distinguished by the presence of one of the most meaningful, gravity-related geomorphological features of the Italian Alps: the Pointe Leysser deep-seated gravitational slope deformation. According to the authors, this complex geosite could be promoted starting from a general overview of the slope, followed by the analysis of individual sites composing it. For doing so, they propose two options: (i) the employment of an app capable of showing the complex geosite as a whole, with a number of detailed insights into the individual elements of the slope; (ii) the use of a dedicated viewpoint geosite (as described by Migoń and Pijet-Migoń [131]) equipped with illustrative panels that might arouse the interest of viewers, who could plan a subsequent visit to the slope to examine some of the single sites. The authors conclude that a combination of the two approaches might be successful in achieving the goal of communicating such a complex and challenging geological environment.

Pasquaré Mariotto et al. [132] have shown a cutting-edge methodology that may enable non-scientific audiences to have access to geosites through immersive and non-immersive virtual reality. To do this, the authors have produced a dedicated WebGIS platform (https://arcg.is/1e4erK0, accessed on 26 November 2022), particularly suitable for communicating geoscience; they have selected nine volcanic outcrops in Santorini, Greece, which were turned into geospatial models—the so-called virtual geosites (VGs)—by means of UAV-based photogrammetry and 3D modeling. Subsequently, the authors have uploaded the nine VGs on an online platform, fully accessible for Earth science teaching and communication. The VGs are now accessible on a smartphone, a PC, or a tablet, and each VG features a detailed description and a number of useful annotations which guide the viewers during 3D navigation.

Martínez-Graña et al. [133] have described how they created a virtual geological itinerary in the Las Quilamas Natural Park, which has an area of 11,100 ha and is part of the Spanish Central System of the Hercynian Massif. They created a virtual map of the area with a series of points of interest (geosites), which can be accessed interactively via a series of geomatics tools such as smartphones, Google Earth, virtual 3D flight modelling, ability to access descriptive information via QR codes, and access to augmented reality.

Lansigu et al. [134], working in a private company whose purpose is to popularize and communicate geosciences, demonstrated how it is possible to raise awareness about geoheritage through a number of cutting-edge visual technologies. To show the validity of their approach to communicating geoheritage and geosites, they focused on the Lubéron Natural Park (Provence, France). Among the various products they have showcased, most noteworthy is the production of a short movie to present the geology of the Alps (in four languages) and the production of a 14-min cartoon with the different elements and geosites that characterize the geoheritage of the park.

Eight geosites with paleontological and geomorphological interest, representative of the Lower and Middle Miocene carbonate deposits near Albufeira in central Algarve (southern Portugal) have been selected by Martínez-Graña et al. [135]. The authors created a virtual 3D tour of the georeferenced geosites using augmented reality techniques and geoinformatic tools. Every stop in the tour is integrated by graphic elements that can be viewed in Google Earth, together with a great deal of information that quantitatively assess the educational and scientific value of the geosites. A virtual flight itinerary, compatible with video formats on smartphones, tablets, and iPads is also provided.

4. Conclusions

Geodiversity and geoheritage have been gaining increasing interest from the scientific community in the last couple of decades. Their most relevant expressions are geosites, which can help bridge the gap between Earth science and the lay public. Geosites must be identified and selected by geologists and geomorphologists based on a deep knowledge of their general and local geological meaning. Their assessment is paramount to ensure that they meet a precise set of prerequisites. The most outstanding effort in geosite assessment was performed in Great Britain in the 1980s and 1990s, when a set of frameworks were established, and the geosites were then assessed within these frameworks. Those assessments could be global, regional, national, or local, based on the best consensus among the scientific community. Once identified and assessed, geosites (also complex ones) can be promoted and communicated so as to educate the lay public in regard to geological topics, enhance geotourism, and increase the education potential of geoparks. In the last few years, technological advancements have made it possible to communicate geoheritage through a number of technologies, including GIS, augmented reality, animated cartoons and, most recently, virtual geosites (VGs). These can be accessed and navigated from home, thus increasing the possibility for the lay public to gain insights into the basic principles and concepts of geology and appreciate the cultural, educational, and scientific values of the selected geosites. Moreover, by taking a preliminary virtual look at geosites, the interest of potential visitors may be aroused, leading them to plan a visit in person.

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