Geological Heritage Management in Small Islands: the Example of the Azores UNESCO Global Geopark (Portugal)

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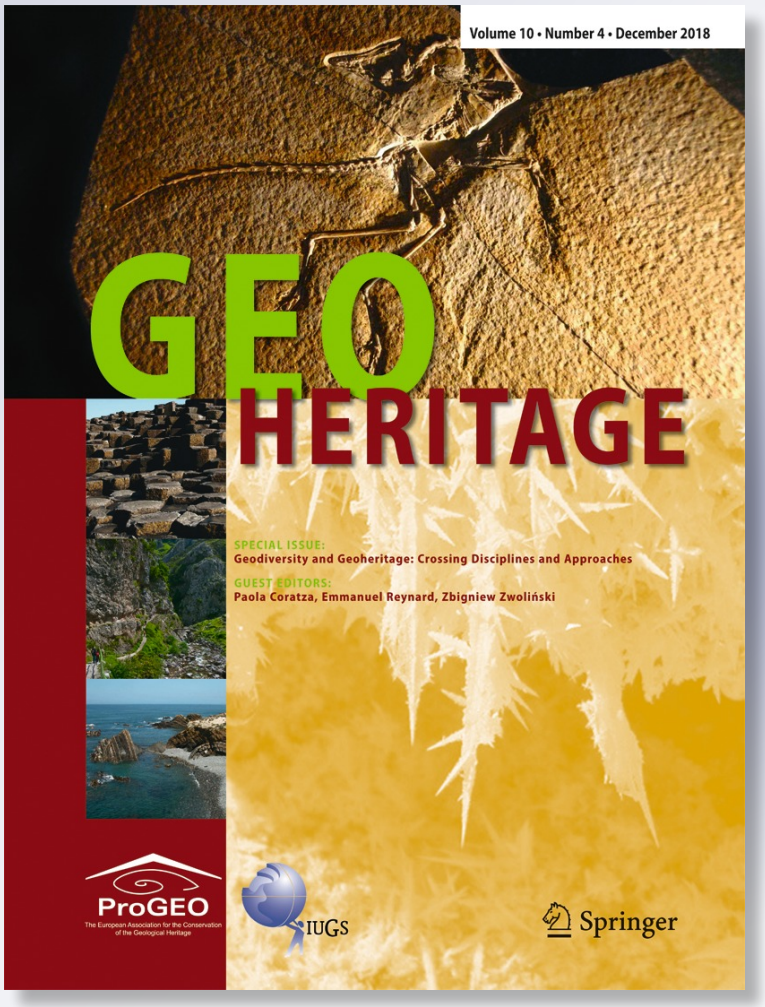

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ORIGINAL ARTICLE

Geological Heritage Management in Small Islands: the Example of the Azores UNESCO Global Geopark (Portugal)

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Abstract

The geological heritage management should be integrated in spatial and environmental planning policies. In small islands, the isolation, small size, and anthropogenic pressures reduce the resilience of ecosystems and increase their vulnerability to global changes, requiring different integrated solutions in comparison with other territories. This case study demonstrates that the geological heritage management in small islands should be made at a local scale allowing the effectiveness of its implementation and the protection of natural resources. It is proposed that this management should be carried out at two levels: (i) an island level, in a strategic way, with clear boundaries and a well-identified set of actors and (ii) a geosite level, in an operative perspective. This proposal is being applied to the islands of the Azores UNESCO Global Geopark ("9 Islands – 1 Geopark"), where 121 geosites are identified. Most of the geosites are included in the Natural Parks of the Island and the Marine Park of the Azores, so it is proposed an integrated management of the geosites in these structures. This facilitates the coordination with other classified areas of each the island and integrates all the territorial instruments and planning processes applied to the island.

Keywords Geological heritage · Management · Small islands · Azores UNESCO Global Geopark

Introduction

The management of geological heritage requires the appropriate support of policies that should result from the integration of nature conservation, environmental planning, land use planning, and environmental education and awareness, in order to involve the public the preservation of their common heritage (Lima et al. 2014).

This is a complex management because it concerns fragile natural elements, but also involves legal, economic, cultural, and usufruct aspects. In addition, management should ensure the conservation of geosites, local development, and the promotion of geological heritage (Carcavilla et al. 2007). It is therefore necessary to establish protocols and mechanisms for the conservation and management of geological heritage.

The territorial management and environmental planning (terrestrial and coastal) is a challenge in insular environments given its isolation and smallness and the fact that they are closed systems (Calado et al. 2007). Small islands are defined when their land area is less than 10,000 km^2, and they have less than 500,000 inhabitants (Beller et al. 2004).

This paper highlights the need for geological heritage management in insular regions, specifically at the Azores UNESCO Global Geopark.

Geoparks in Small Islands

According to UNESCO (2016), UNESCO Global Geoparks are single, unified geographical areas where sites and landscapes of international geological significance are managed with a holistic concept of protection, education, and sustainable development.

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Currently, there are 127 UNESCO Global Geoparks in 35 countries, being also part of the Global Geopark Network (Fig. 1). Ninety-two of them are continental areas and the other 35 are insular. Regarding the definition of Beller et al. (2004), 7 geoparks are small in terms of area but in terms of population they do not fulfill the condition, and the other 7 are considered geoparks in small islands (e.g., Lesvos Island UNESCO Global Geopark, Langkawi UNESCO Global Geopark, Shetland UNESCO Global Geopark, Oki Islands UNESCO Global Geopark, Azores UNESCO Global Geopark, El Hierro UNESCO Global Geopark, Qeshm UNESCO Global Geopark, with inhabitants census data from 2003/2016).

Azores UNESCO Global Geopark

The Azores archipelago is a Portuguese Autonomous Region composed of nine islands, several islets, and the surrounding seafloor, located in the middle of the North Atlantic Ocean on the triple junction between the North American, Eurasian, and African (or Nubian) plates. It is characterized by the small size of the islands (17 to 745 km^2), by its dispersion (over 600-km length), and by the distance to the European and American continents (1815 km from Portugal mainland and 2625 km from Canada), being considered a European ultra-peripheral region (Fig. 2).

All the islands of the archipelago are considered small islands according to the classification proposed by Beller et al. (2004) (Table 1).

The Azores geodiversity is strongly related to the dynamics of the planet Earth, in particular with volcanism and geotectonics of the Mid-Atlantic Ridge. The archipelago is a natural laboratory of volcanic geodiversity, with different types of volcanoes, hydrothermal fields, volcanic ridges, volcanic lakes, black sand beaches, and volcanic caves, among others, despite its small terrestrial area (2332 km^2) (Nunes et al. 2011; Lima et al. 2014).

In the last decade, the geological heritage of the archipelago has been inventoried, characterized, quantified, protected, and promoted (Lima 2007; Brilha et al. 2009; Nunes et al. 2011; Brilha and Pereira 2012; Lima et al. 2014). Given the insular nature of the region, the Azores Geopark is supported on a network composed of 121 geosites, dispersed by the nine islands and the surrounding seafloor.

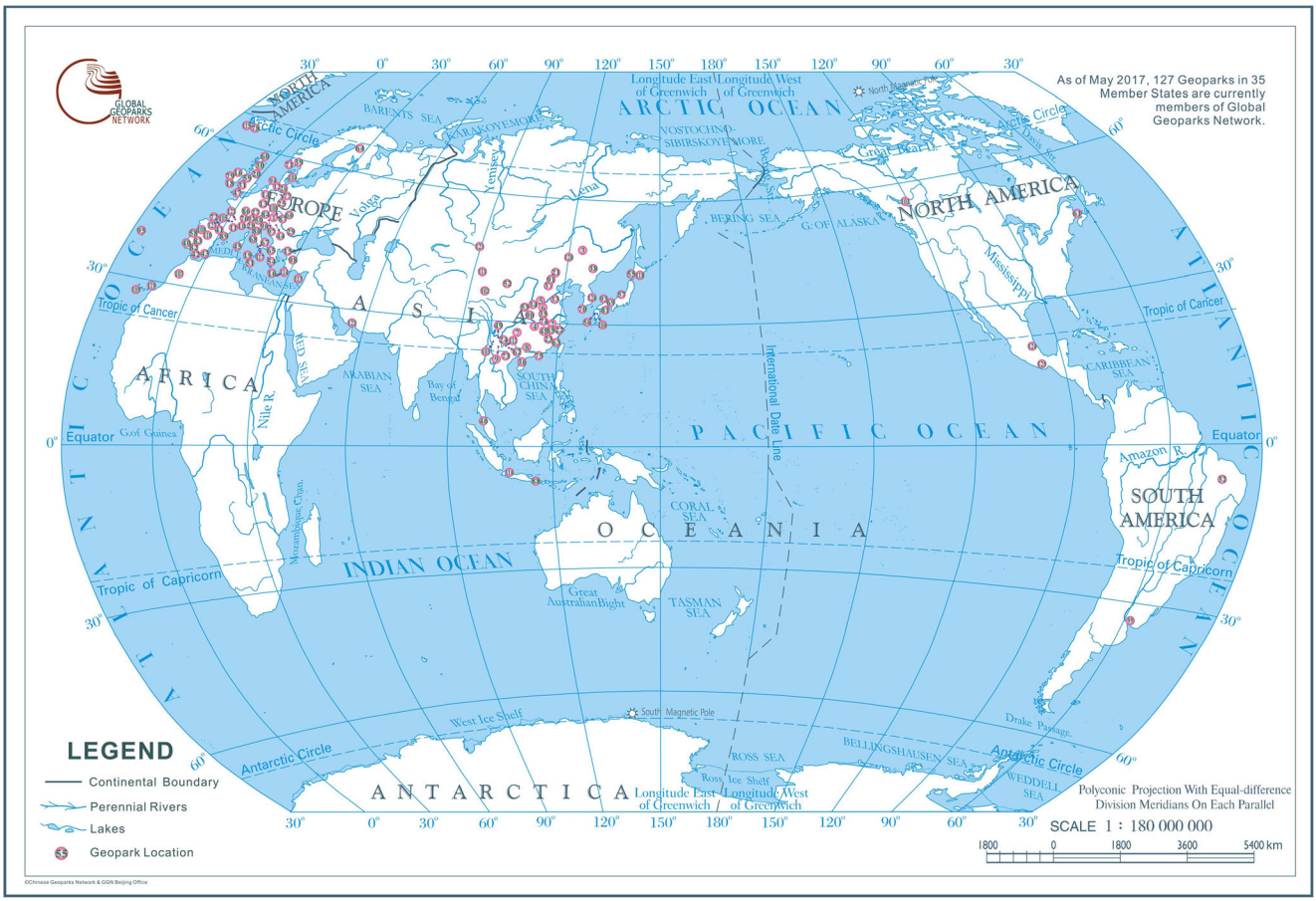

Fig. 1 Global Geoparks in 2017 (available at www.globalgeopark.org)

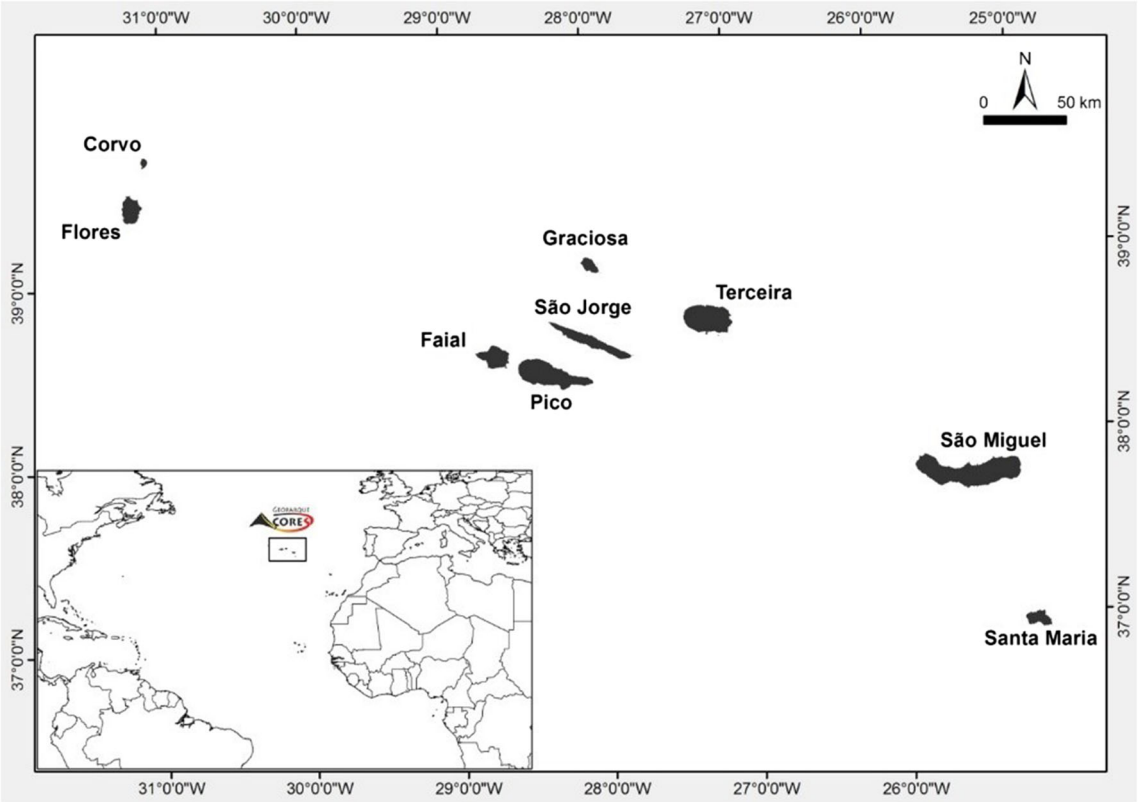

Fig. 2 Geographical setting of the Azores archipelago

The network of geosites (i) ensures the representativeness of the geodiversity that characterizes the Azorean territory, (ii) reflects the geological and eruptive histories, (iii) has common conservation and promotion strategies, and (iv) based on a decentralized management structure with support in all the islands (Nunes et al. 2011) (Fig. 3).

The high number and quality of the geosites, the international relevance of the Azorean geological heritage (6 geosites—Figs. 4, 5, 6, 7, 8, and 9), and the importance of its geodiversity, together with the existence of a rich biodiversity and a remarkable cultural heritage, sustain the Azores Geopark with the motto of "9 Islands - 1 Geopark." This archipelagic geopark has been included in the European and Global Networks of Geoparks since March 2013 and since November 2015 has been recognized as one of the UNESCO Global Geoparks, a territory where everyone is invited to "Enjoy flavours, smells and experiences!"

Table 1 Characteristics of the Azores islands

Island	Area (km^2)	Inhabitants (census 2011)
Santa Maria	97	5552
São Miguel	745	137,856
Terceira	401	56,437
Graciosa	61	4391
São Jorge	244	9171
Pico	445	14,148
Faial	173	14,994
Flores	141	3793
Corvo	17	430

Geosites vs Protected Areas

There are protected areas in the Azores archipelago since 1976, the first ones being of geological interest, the Caldera from Faial Island and Pico Mountain (Lima 2007). The Regional Legislative Decree no. 15/2007/A n.d. reclassifies protected areas of the archipelago by the categories of the International Union for Conservation Nature (IUCN) and integrates geological elements for the first time into regional and national environmental legislation (Lima et al. 2014). The Island Natural Parks, created by the mentioned law, are structures that allow the management of the territory with the aim for conservation of the natural diversity, as well as to the sustainable use of the natural resources, in order to promote the tourism and well-being of the populations. On the other hand, marine protected areas are gathered in the Azores Marine Park

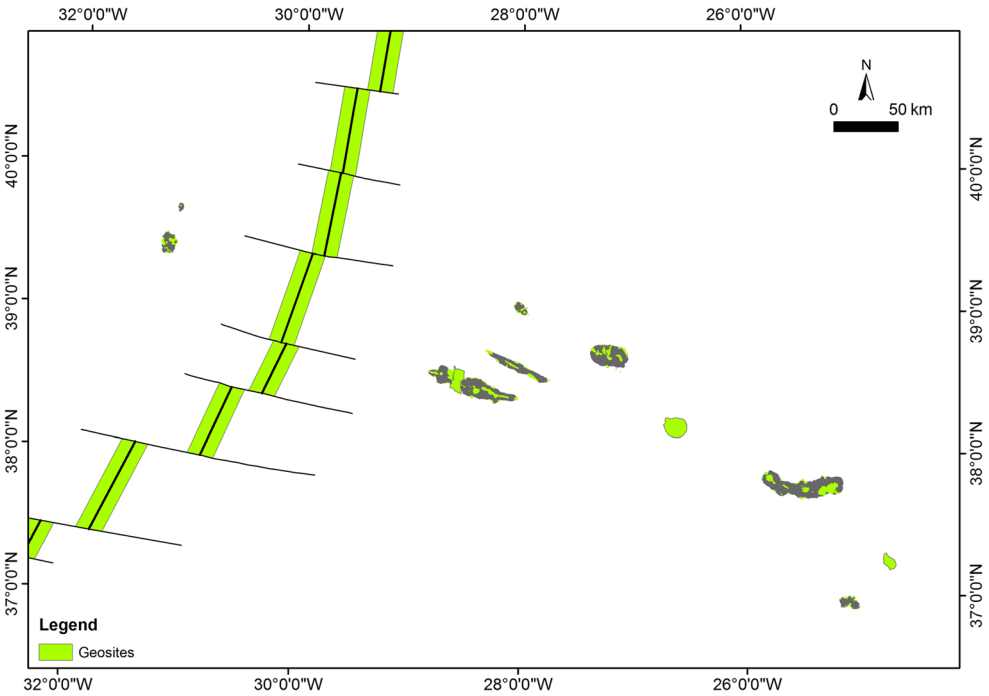

Fig. 3 The Azores UNESCO Global Geopark 121 geosites (Nunes et al. 2011)

(Regional Legislative Decree no. 28/2011/A n.d. and no. 13/2016/A), which aims to contribute to the protection and management of marine areas by the Azores Regional Government.

Significant number of geosites (93) overlaps with the Island Natural Parks and the Marine Park, with 49 geosites inside protected areas. Several geosites are also classified by international conventions such as the Natura 2000 Network, Man and Biosphere (MAB), Ramsar Sites, UNESCO World Heritage, Important Bird Areas (IBA's), and OSPAR Zones. Only 19 geosites occur in areas without any sort of classification or protection (Nunes et al. 2011; Lima et al. 2014) (Figs. 10, 11, 12, 13, 14, 15, 16, 17, 18, and 19 and Table 2).

São Miguel and Pico islands have the largest number of geosites (27 and 18, respectively) and protected areas (23 and 22), and surface covered (142 km^2 and 157 km^2) by those designations. These islands are also the ones with the largest area with overlap of both classifications (93 km^2 and 58 km^2).

On the other hand, Corvo, the smallest island of the archipelago, presents small numbers and area of geosites (4 geosites and 6 km^2) and protected areas (2 protected areas and 8 km^2); however, it is the one that presents the most

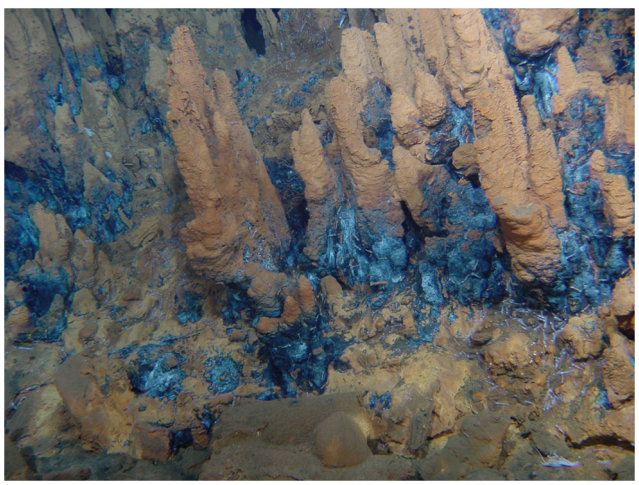

Fig. 4 Mid-Atlantic Ridge and deep sea hydrothermal fields. Photo by: Missão Seahma, 2002 (FCT/PDCTM 1999/MAR/15281)

Fig. 5 Furnas volcano caldera, São Miguel Island. Photo by Eva Lima

Fig. 6 Pico Mountain, Pico Island. Photo by Eva Lima

surface proportion covered by geosites (34%), protected areas (45%), and overlapping of both (24%). Graciosa and Santa Maria islands also have low values in several parameters of the table.

It is important to mention that 16% of the terrestrial territory of the archipelago is geosites and 24% is protected areas.

About the marine areas, it is important to mention that the geosites are restricted to the Azores UNESCO Global Geopark area, which corresponds to the emerged territory of the nine islands, the respective islets, and four marine geosites, and the Azores Marine Park includes the marine protected sites that are located beyond the outer limit of the territorial sea and the exclusive economic zone. Despite the large area of marine geosites (10,561 km^2) and the huge area of marine protected areas (245,917 km^2), they only overlap in 748 km^2.

Fig. 7 Graciosa caldera volcano and Furna do Enxofre volcanic cave, Graciosa Island. Photo by Eva Lima

Fig. 8 Capelinhos volcano and Costado da Nau volcano, Faial Island. Photo by Eva Lima

Geological Heritage Management in Small Islands: Example of the Azores UNESCO Global Geopark

Due to the geographical isolation and the ecological characteristics, small islands are more vulnerable systems to natural changes, such as the global climate changing, and anthropogenic pressures, such as land use changes (Saffache and Angelelli 2010), that threaten and compromise their sustainable development, with emphasis on nature conservation (Lima et al. 2012), making the management of natural resources quite a challenge.

According the characteristics described in the previous chapters, it is intended to define a methodology in more details for the management of the geological heritage of the archipelago, in order to be compatible with

Fig. 9 Algar do Carvão volcanic pit, Terceira Island. Photo by Eva Lima

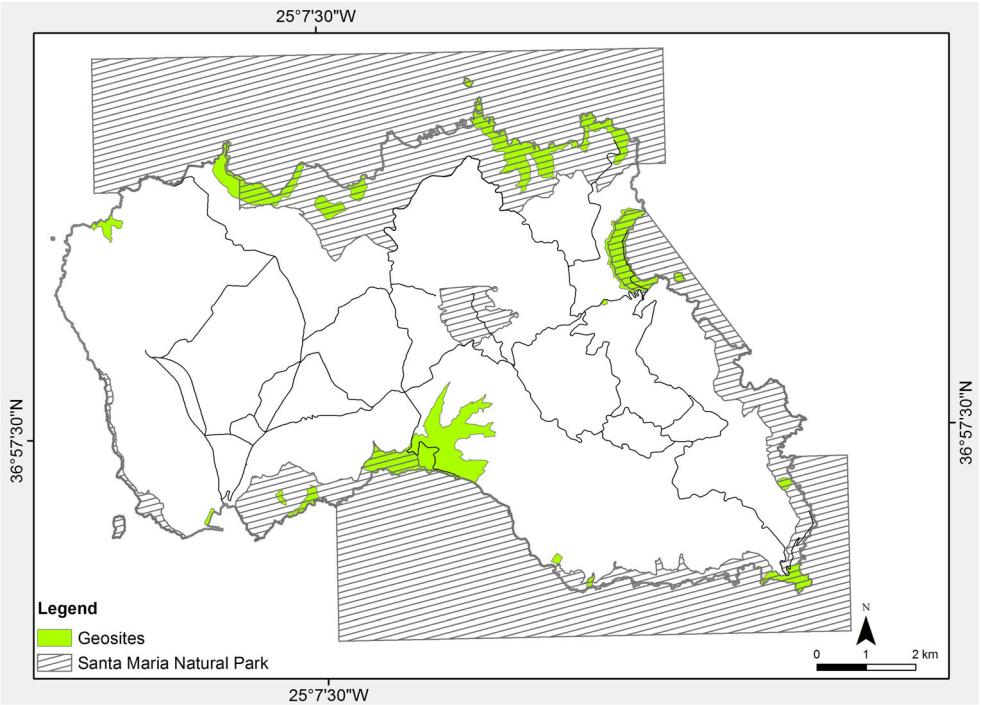

Fig. 10 Geosites vs Santa Maria Natural Park (15 geosites and 13 protected areas)

the usufruct and geoconservation, to maintain the quality of geosites and pass this important legacy to future generations.

The purpose is to manage the geological heritage on small islands at two levels: (i) at the island level, as strategic, and (ii) at the level of each geosite, as operational.

Management at an Island Level

The aim is to include the management of the geological heritage in the management already carried out by the Island Natural Parks, since most of the geosites are also previously classified and protected areas, as already mentioned. It is pur-

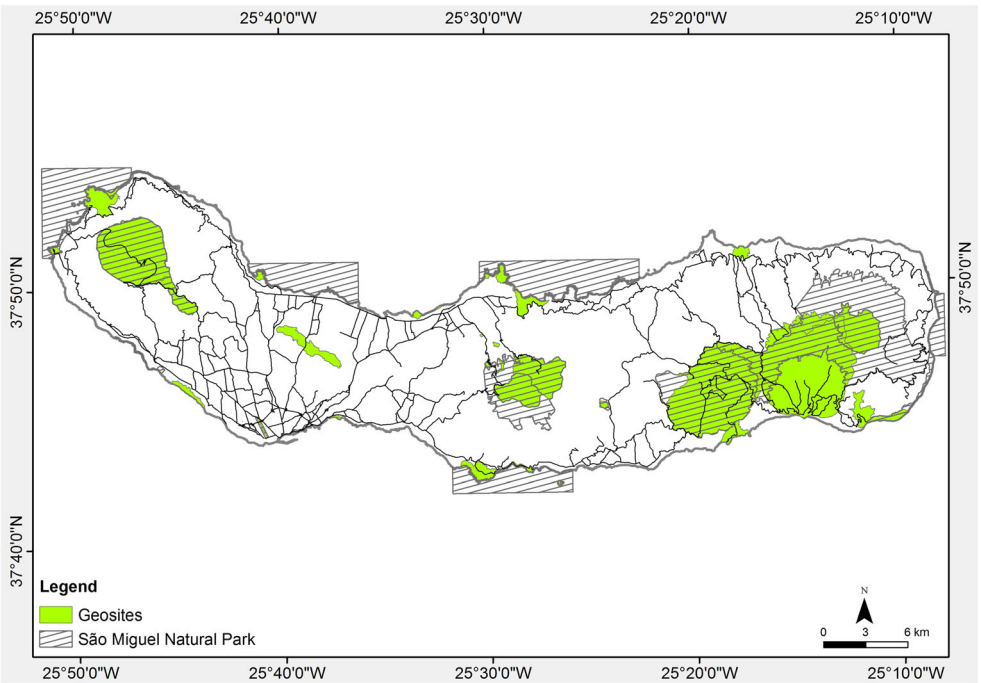

Fig. 11 Geosites vs São Miguel Natural Park (27 geosites and 23 protected areas)

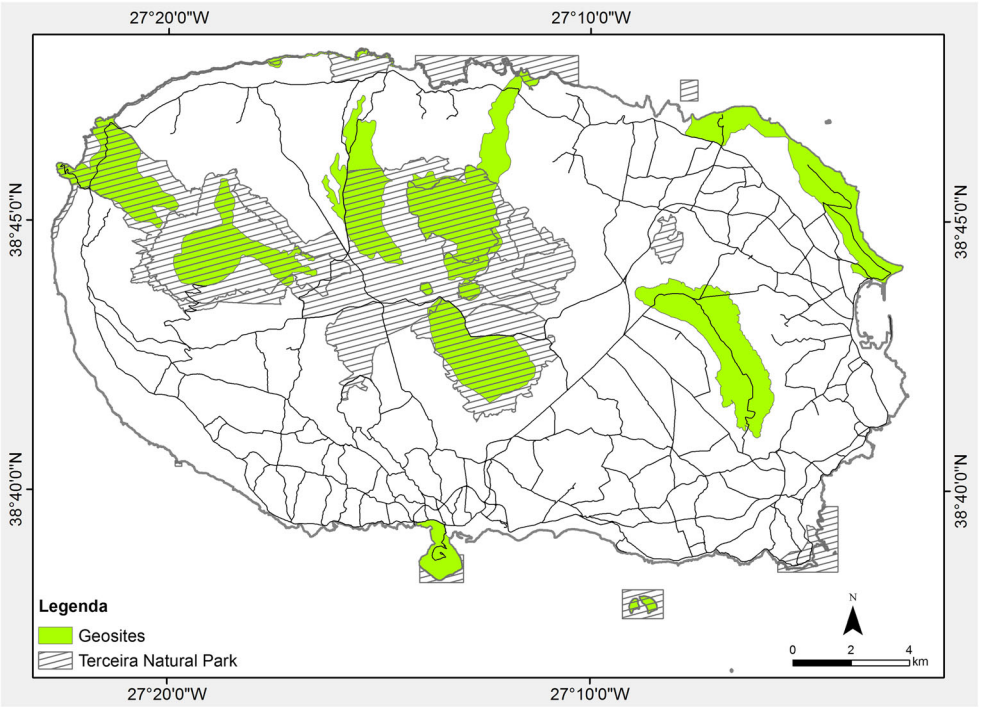

Fig. 12 Geosites vs Terceira Natural Park (13 geosites and 20 protected areas)

posed to analyze the approaches and proposals of planning, management, and geoconservation, involving all the municipal, regional, and sectorial territorial planning instruments implemented in the island, which determinants and guidelines are taken into account in the management of the geological heritage (Lima 2015).

The management of the geological heritage at an island level facilitates the logistics because (i) the territorial delimitation is well defined, i.e., the boundaries of the island; (ii) the territorial delimitation ensures the continuity of the geological processes; and (iii) the actors and stakeholders are easily identifiable (Lima et al. 2015).

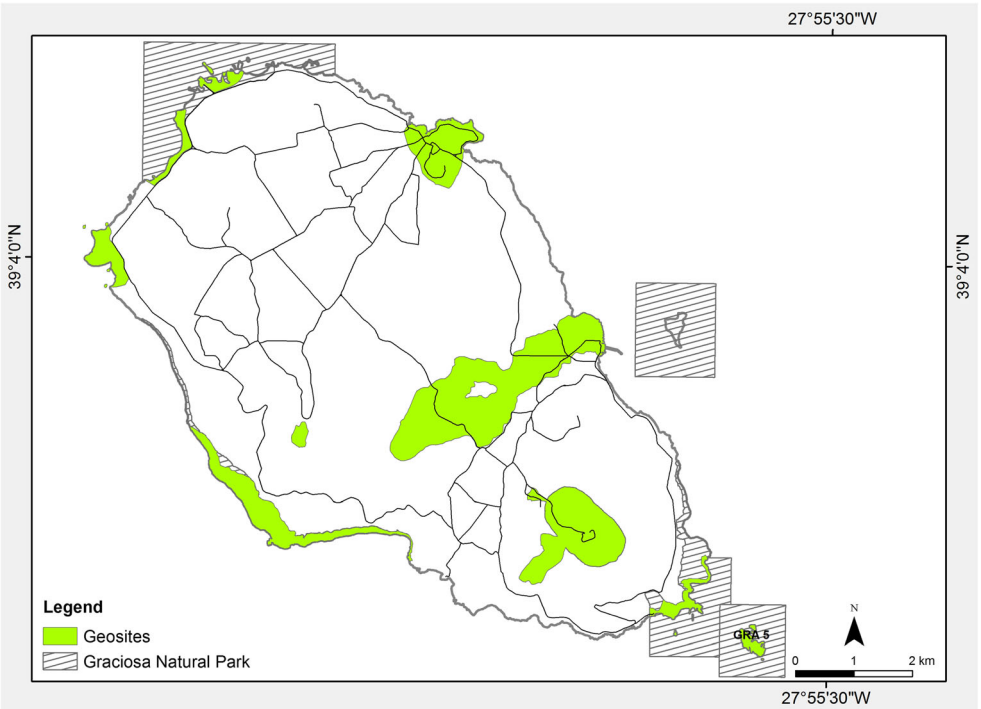

Fig. 13 Geosites vs Graciosa Natural Park (9 geosites and 8 protected areas)

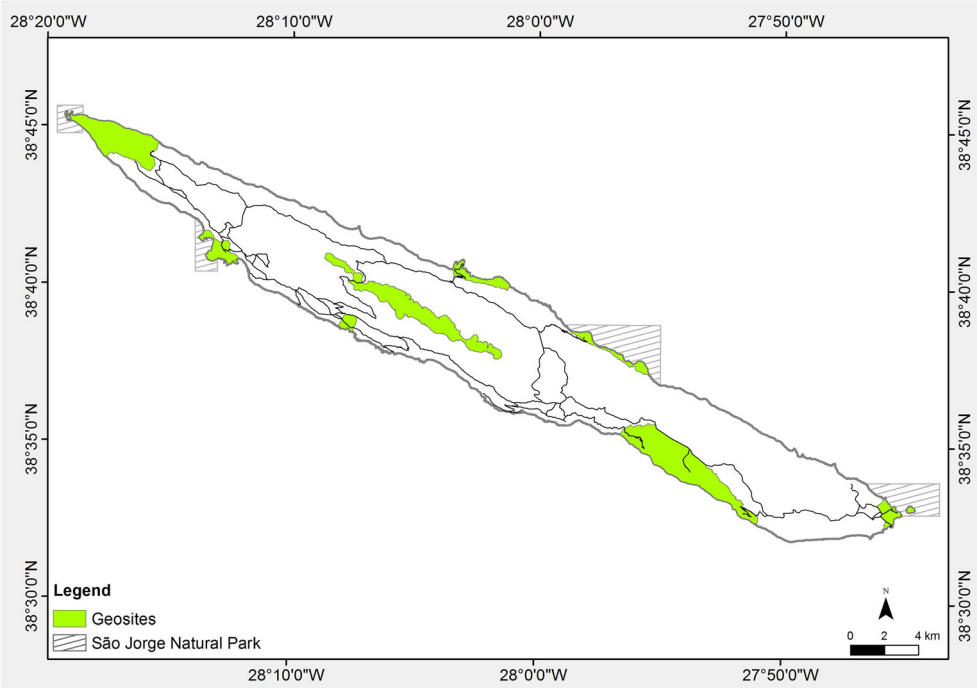

Fig. 14 Geosites vs São Jorge Natural Park (8 geosites and 13 protected areas)

The integration of the management of the geological heritage in the Island Natural Park also simplifies its implementation because (i) the Island Natural Parks are the island's management unit that covers all protected areas; (ii) it manages the island's environmental affairs; (iii) the directors of the Island Natural Parks are also the representatives of the Azores Geopark on each island; (iv) the rangers of the Island Natural Parks are in the territory daily; (v) it concentrates on a single logistics entity; and (vi) it minimizes costs.

Management at a Geosite Level

At the geosite level, it is proposed to carry out the monitoring.

The monitoring of geosites is considered one of the main steps in a geoconservation strategy, ensuring better

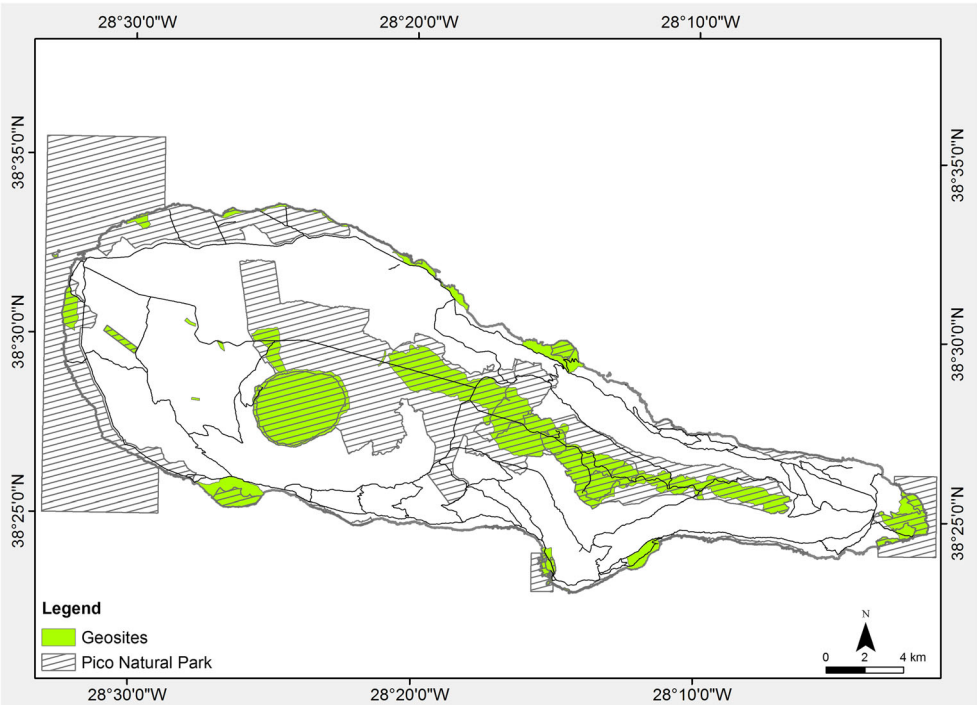

Fig. 15 Geosites vs Pico Natural Park (18 geosites and 22 protected areas)

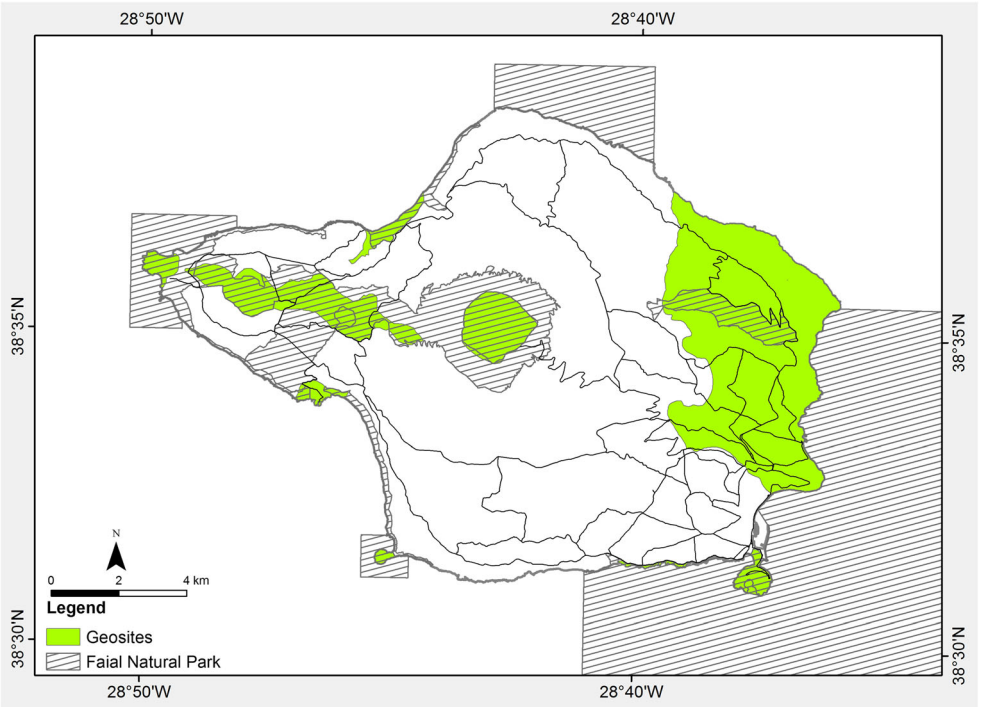

Fig. 16 Geosites vs Faial Natural Park (9 geosites and 13 protected areas)

conservation of the geological heritage and its management. Its aim is to look after the evolutionary state of the geosite and its integrity, identify threats (anthropogenic and natural), and quantify the (eventual) loss of relevance over time. During the monitoring, visitors' characteristics at the geosite are recorded, as well as activities developed in the area (Lima 2012).

The geosites monitoring in the Azores Geopark began experimentally in the years 2011 and 2013. Since 2014, it has been made on a monthly basis, all year round, in all the terrestrial geosites. The management partnership referred at the island level is operationally expressed at this level, since monitoring is carried out with the collaboration of rangers from all Island Natural Parks, who have had specific training to carry out this task (Lima 2012; Lima et al. 2014) (Table 3).

In the balance of the monitoring work already carried out, it is verified that (Ponte et al. 2015):

- the geological characteristics of the geosites are in good condition and without serious natural and anthropogenic threats;
- the most visited geosites offer good conditions for their usufruct and adequate infrastructures (viewpoints, parking, and trails);
- most of the geosites are clean but there are occasional problems of accumulation of waste;
- most of the visitors are in tourism or leisure activities, followed by professionals doing some maintenance and conservation, and students in environmental education, awareness, and conservation actions;
- the majority of the visitors respect the rules of the geosite.

It is intended to use the obtained information to adapt the geoconservation strategies that can meet the needs of each site in order to consolidate measures to maintain the quality of the geosite and reduce the problems encountered.

The Azores Geopark launched the challenge of monitoring submarine geosites to the dive companies. The initial tasks of this work are based on the definition of the methodology to be implemented and parameters to be analyzed, in collaboration with companies that have adhered to the challenge.

Society Involvement

The promotion and enhancement of geological heritage are important contributions to its management. It is essential that all the society could be involved in this objective. On behalf of the geopark technical team (specialists/geoscientists and staff) and its partners, the local

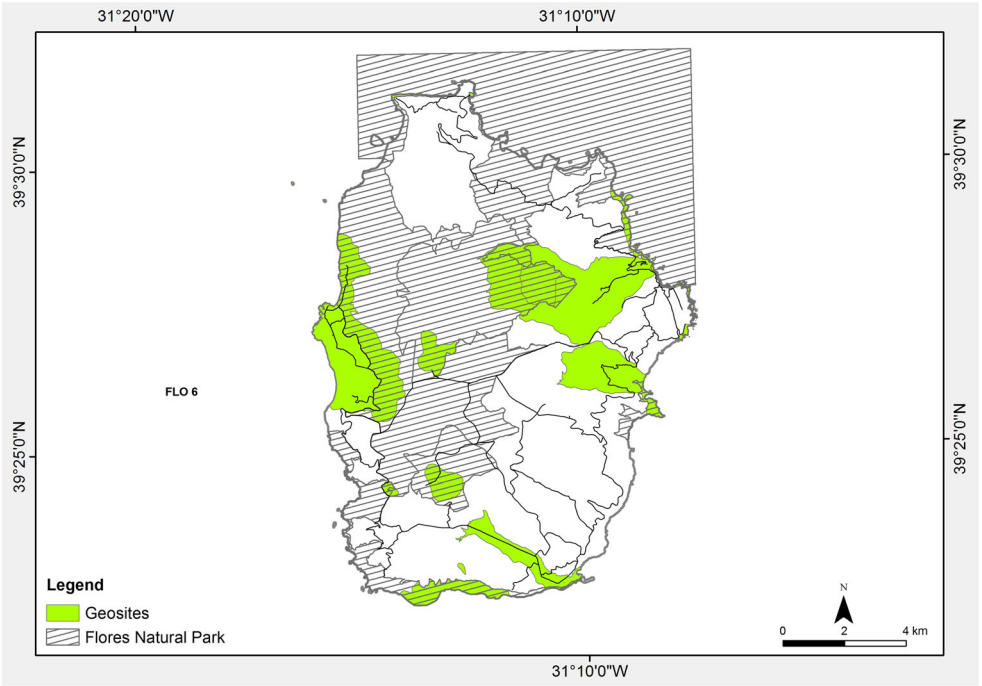

Fig. 17 Geosites vs Flores Natural Park (14 geosites and 9 protected areas)

population and the visitors recognize the value of the geological heritage, for this contributes several actions of communication and interpretation carried out by the Azores Geopark and its partners, for example, distribution of information through the regional media (weekly radio magazine, newspaper) and available interpretational materials (panels, leaflets, mobile applications). Educational programs on geodiversity and geoconservation are available for all age groups and for the development of quality nature tourism in the territory, training courses and other technical support are carried out for public and private entities.

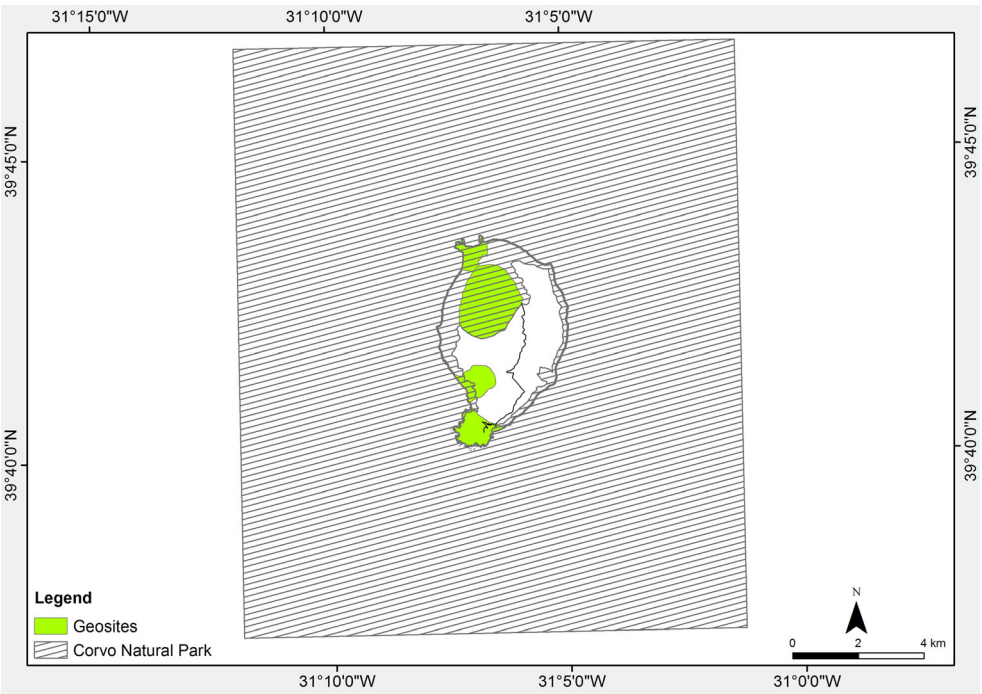

Fig. 18 Geosites vs Corvo Natural Park (4 geosites and 2 protected areas)

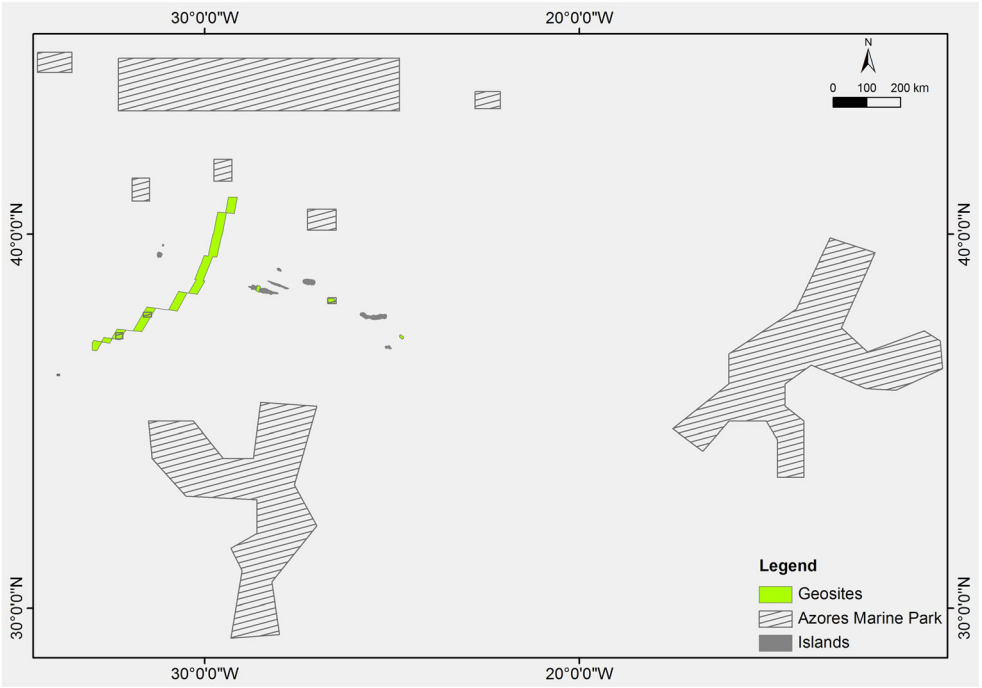

Fig. 19 Geosites vs Azores Marine Park (4 marine geosites and 15 marine protected areas)

Final Notes

The management of the natural heritage, and specifically the geological heritage, in small islands is a sensitive issue. Small islands are considered largely coastal entities and are vulnerable systems to natural changes, such as the global climate changing, and anthropogenic pressures, such as land use changes (Saffache and Angelelli 2010).

All the islands of the Azores are considered small and most of their geosites are integrated into the protected areas of the archipelago. From a feasibility perspective, it is proposed that the management of the geological heritage in the Azores islands is done at two levels: (1) at the island level, because the boundaries of its territory and stakeholders are well defined, which facilitates its operationalization by concentrating logistics in a single entity (the Island Natural Park) in collaboration with the Azores UNESCO Global Geopark, and (2) at the level of each geosite, the operation is operationalized through its monitoring.

Table 2 Geosites vs protected areas

Island	Number of geosites	Geosite area (km^2)	Island area cover by geosites (%)	Number of protected areas	Area of protected areas (km^2)	Island area cover by protected areas (%)	Area that overlaps geosites and protected areas (km^2)	Area of the island that overlaps geosites and protected areas (%)
Santa Maria	15	6	6	13	17	17	4	4
São Miguel	27	132	18	23	142	19	93	13
Terceira	13	56	14	20	86	21	33	8
Graciosa	9	8	13	8	7	12	3	5
São Jorge	8	34	14	13	57	23	14	6
Pico	18	66	15	22	157	35	58	13
Faial	9	40	23	13	30	17	14	8
Flores	14	29	20	9	61	43	13	9
Corvo	4	6	34	2	8	45	4	24
Marine areas	4	10,561	–	4	245,917	–	748	–
Azores	121	10,938	16	127	246,482	24	984	–

Table 3 List of parameters monitored at the Azorean terrestrial geosites

Geosite identification	Geosite and monitoring point identification
Weather conditions	Observed
Visitors' characteristics	Number of visitors
	Observed uses (recreational, educational, conservation)
	Transport used (car, motorcycle, auto bus, by foot, other)
	Respect of the rules of visitation
Geosite conditions	Cleanliness (clean, with dispersed waste, with illegal deposits of waste)
	Conditions of the monitoring point (clean, with dispersed waste, with illegal deposits of waste)
	Access conditions (clean, with dispersed waste, with illegal deposits of waste; transit ability in good conditions, bad conditions, impassable)
	Signals (viewpoint, point of interest, geosite, rules, interpretation panel, other)
Geological heritage conditions	Conservation state (perfectly conserved, with some anthropic alteration, some anthropogenic changes but do not prevent the observation of geological characteristics of interest, severe anthropogenic changes that deteriorate the geological characteristics of interest)
	Observation (great conditions, reasonable, with difficulty)
	Natural evolution (erosion, landslides, propagation of vegetation, change of water level, other)
	Observed anthropic threats (touristic pressure, urban pressure, agricultural pressure, waste, other)
	Observed natural threats (vegetation, erosion, landslides, other)

In all this process, the geoscientists provide the management guidelines so the others technicians, from the Azores UNESCO Global Geopark and their partners, can operate after them. For the success of this methodology, it is important to keep a good cooperation between the Azores UNESCO Global Geopark and the Island Natural Parks.

The management and promotion of the geological heritage of a territory should be as transversal as possible because the more people are involved and committed in the valuation of their heritage, the better their management will result!

The Azores Geopark has an important role in the promotion of its geological heritage to the local population and geotourists through various products and actions of interpretation of geoparks, environmental awareness, and promotion of geotourism.

Given its characteristics (area, dispersion of islands, and their genesis), the proposed methodology can also be adapted to the other archipelagos of Macaronesia (Madeira, Canary, and Cape Verde Islands).

The next steps in this work are the definition of management objectives by categories of geosites; the zoning of larger geosites, with different management objectives; and the definition of carrying capacity for touristic use of geosites, as a tool for the sustainability and tourism both with the aim of valuing of the natural resources of the Azores.

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