Geoheritage (2021) 13: 106
https://doi.org/10.1007/s12371-021-00635-y

ORIGINAL ARTICLE

Geoconservation in the Autonomous Region of the Basque Country (Spain)

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Received: 19 December 2020 / Accepted: 9 November 2021 / Published online: 1 December 2021

Abstract
The Basque Country is an autonomous region located in the north-east of Spain and presents a high geodiversity index and international significant geoheritage. In this territory, there are two UNESCO designations: Urdaibai Biosphere Reserve and Basque Coast Global Geopark. Both bodies follow the path to sustainability taking into account nature management in a holistic way and complementing it within a consensual geoconservation strategy for the whole country. This strategy tries to reach an agreement between administrations and citizenship, arranging objectives and actions to achieve correct management of the Basque geosites. This paper aims to describe the actions within the framework of geoconservation that the Basque Country has carried out over the last 40 years, enabled by its exclusive competences in environmental, cultural and territorial planning. We aim to explain how, from local management, it is possible to implement a coordinated and effective policy in relation to geoheritage conservation and management.

Keywords Basque · Geoconservation · Strategy · Urdaibai Biosphere Reserve · Basque Coast UNESCO Global Geopark

Introduction

Geodiversity is a common good that is an undisputed part of the natural diversity of any territory (Gray 2013). It forms the basis on which biodiversity settles, and conditions its development (Crofts 2019). In addition, it represents the memory of our planet (Gray 2019). In the scope of environmental and territorial and even economic or cultural management, the role that geodiversity plays in the ecosystems services is recognized as fundamental (Gordon et al. 2018). We can also consider it as the physical basis of our varied landscapes (Reynard and Giusti 2018), the materials that make up our houses or the way we settle in the territory that we have had in the past (Richards et al. 2020). Moreover, it is a fundamental educational and informative resource to publicize the formation and evolution of our mountains, rivers, estuaries, minerals, fossils or rocks (Tormey 2019). It also shows us the future evolution and trends of many processes or risks that govern our day-to-day life, such as storms, floods, rock landslides or climate change (Fuertes-Gutiérrez and Fernández-Martínez 2012). Furthermore, geodiversity presents often a strong link to cultural elements such as mythology, surnames or names of our towns or neighbourhoods (Neches 2013). In short, geodiversity is a resource of great natural, scientific, didactic, cultural and economic importance (Carcavilla et al. 2007), and the environmental, territorial and cultural management policies of any territory must integrate it in order to properly know and interpret our current and past environment; in this way, predict and adapt to future changes (Gordon et al. 2018). In Spain, geoconservation has advanced considerably recently, due to the perception of some geological elements as geoheritage and part of natural heritage (Díaz-Martínez et al. 2014). This trend is helped decisively by the consideration of geoheritage as an economic resource on territories via geotourism, especially in protected areas (Hose 2012).

The Spanish legislative framework for the protection of geoheritage is one of the most favourable at the European level. The current statutory framework for the geoheritage protection in Spain consists mainly of natural heritage

This article is part of the Topical Collection on *The Oxford Geoheritage Virtual Conference: Reshaping discourse in a time of social distancing*

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legislation (Law 42/2007). In addition, paleontological heritage in some regions is regulated through historical and cultural heritage legislation (Law 16/1985), even though in principle, only the elements that result from human activity should be within the scope of this law (Díaz-Martínez et al. 2013). Land-use planning legislation (Royal Legislative Decree 2/2008) can also be an instrument for the protection of geoheritage through the consideration of the territory as a preserved soil in territorial and urban planning, by virtue of its geological interest.

The aforementioned Law 42/2007 refers to the development of a Spanish Inventory of Natural Heritage and Biodiversity (SINHB), which is regulated by Royal Decree 556/2011. This inventory allows (1) to know the state of conservation of natural heritage and the causes that determine its changes; (2) to design conservation, management and sustainable use policies and actions; and (3) to disseminate the values of that heritage to the society. The Spanish Government develops and updates the SINHB with the participation of regional governments and the collaboration of scientific institutions and organizations.

The Strategic Plan of Natural Heritage and Biodiversity 2011–2017 (Royal Decree 1274/2011) entrusts the Spanish Geological Survey (IGME-CSIC) with the completion of the Spanish Inventory of Geosites (SIG), which is integrated with SINHB. It is composed of sites selected due to their uniqueness or representativeness and/or their relevance for the study and interpretation of the origin and evolution of the Spanish geological domains, including the processes that have modelled them, the climates of the past and their palaeobiological evolution (Annex I. 5.d of Royal Decree 556/2011). These domains also encompass the geological units and contexts of Annex VIII of Law 42/2007.

On the other hand, Law 45/2007 on Sustainable Development of the Rural Environment proposes the development of geological and mining tourism and the use of geological resources to promote sustainable development in the rural environment and to promote initiatives for the knowledge, protection and sustainable use of geological and mining heritage as a scientific, cultural and touristic resource.

Finally, Law 5/2007 (National Parks Network) includes in its annexes a list of natural geological systems that must be represented in this network (Díaz-Martínez et al. 2008).

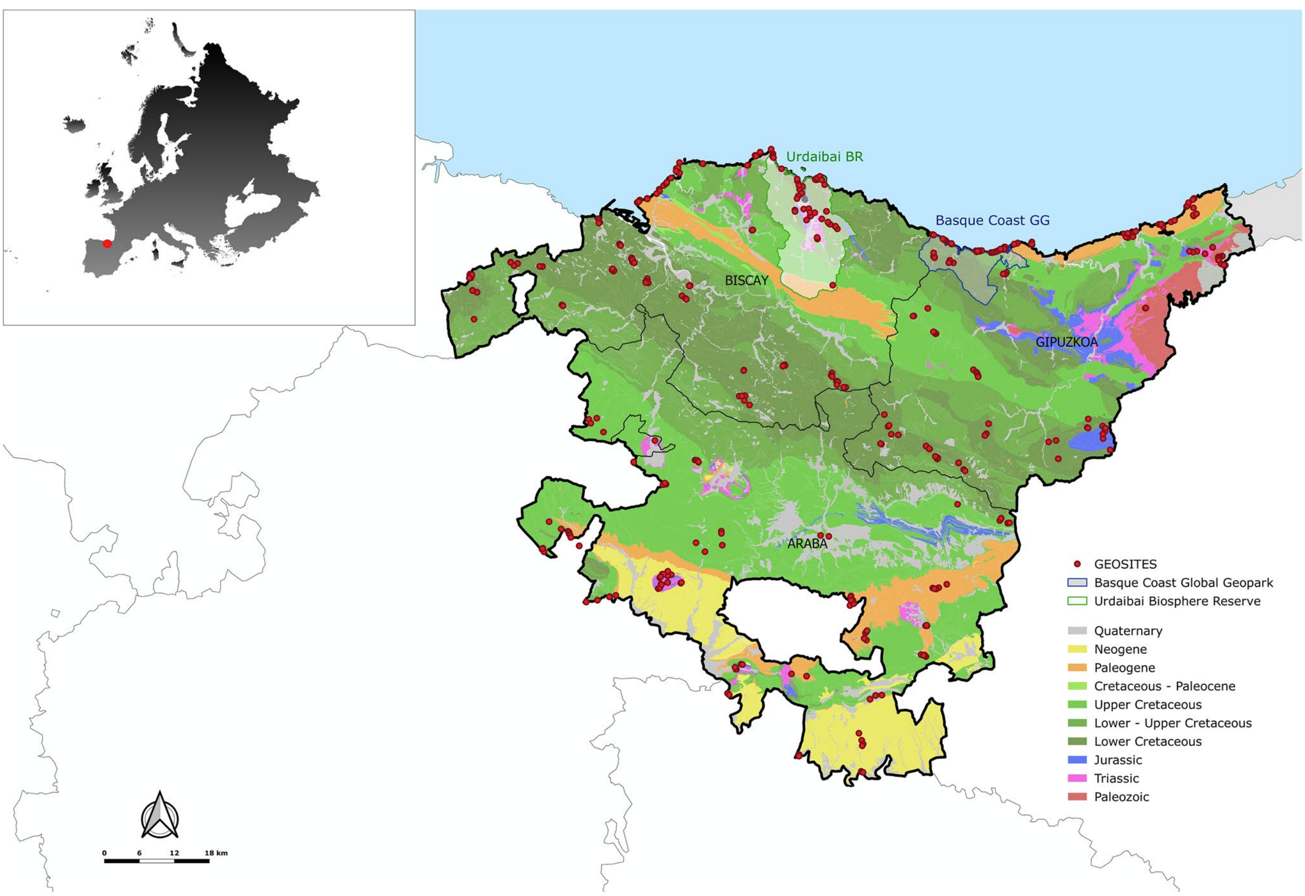

Fig. 1 Location and geology of the Basque Country. Red dots correspond to its 150 inventoried geosites. It also shows the limits of the Urdaibai Biosphere Reserve and the Basque Coast Global Geopark

The Basque Country has 7234 km^2 and 2.2 million inhabitants and is located in the south-east of the Bay of Biscay (Fig. 1). As a significant legislative element, the statute of autonomy defines all the competences of the Basque Country, both those exclusive to it, including the environmental and land planning competences among others, and those corresponding to the implementation of the basic legislation of the Spanish state. Because of this law, the inventory of geosites approved by the Basque Country becomes part of SGI and thus of SINHB.

This paper aims to describe the geoconservation actions that the Basque Country has carried out over the last 40 years based on its exclusive competences in environmental, cultural and territorial planning. It is a question of explaining how from local management it is possible to implement a coordinated and effective management policy in relation to geoheritage.

The Basque Country: a Piece of the Geological History of the Earth

There is an excellent geological knowledge of the Basque Country as a result of research works dating back to the eighteenth century (Gómez-Tejedor 1983), among which it is worth noting a few very prolific authors of the nineteenth century such as Schulz (1845), Verneuil et al. (1860), Carez (1881) and Adan de Yarza (1885). From the middle and end of the twentieth century to the beginning of the twenty-first century, there have been scientific works mainly led by researchers from the University of the Basque Country (Vera 2004) and cartographic works (EVE/EEE 2002) led by the Energy Agency of the Basque Government and/or by Spanish IGME-CSIC.

The Basque Country is located in the Basque–Cantabrian Basin (Fig. 1). It is bound by the Asturian Palaeozoic Massif to the west and the Basque Palaeozoic Massifs and the Pyrenees to the east. To the south, its limits are the Tertiary Basins of the Douro and the Ebro rivers, while to the north, it extends to the Bay of Biscay. The present landscape of the Basque and surrounding areas is the result of a long geological evolution (Vera 2004; Bodego et al. 2014). About 267 Ma ago, the Iberian Peninsula, where the Basque country is integrated, was part of Pangea, which embraced most emergent landmasses of the Earth. Following the breaking-up of this supercontinent, the north margin of the Iberian Peninsula was stretched and began to sink, becoming transformed into a 'basin' (so-called Basque–Cantabrian Basin) that was infilled by a thick pile (> 10 km) of sediments during the next 200·Ma.

Stage 1: 375–260 Ma

A deep sea covered a Basque Country located between two large continents called Laurasia to the north and Gondwana to the south. About 300·Ma ago, they approached each other until the clash between them gave rise to a unique continent called Pangea and erected a large mountain range known as the Variscan Orogeny (Franke et al. 2020). That collision generated pressures and temperatures that managed to melt part of the Earth's crust. This molten material ascended in the form of large bags of magma placed a few kilometres from the surface. Its slow cooling resulted in the crystallization of granites (in red in Fig. 1) that today we see at Aiako Harria (Heddebaut, 1970). This bag of magma stayed about 4 km below the surface about 267·Ma ago. Moreover, some metamorphic rocks around this granite are the best witnesses to the great collision that gave rise to Pangea (Pesquera and Velasco 1988; Olivier et al. 1999). Other rocks of north-east Gipuzkoa recorded this stage as well. For instance, the Arditurri mining environment and Añarbe reservoir (Gipuzkoa) are located on clays, sandstones and small conglomerates deposited in that Devonian sea 370·Ma ago that we can today see transformed into slates, sandstones and shale due to the changes suffered during their folding and lifting (Pesquera 1985).

Stage 2: 260–205 Ma Ago

From 248 to 230·Ma ago, the surface of Pangea began to crack, resulting in depressions where huge amounts of eroded sediments from the mountains accumulated at the base of the main reliefs and in the riverbeds. Thus, the great alluvial fans of the Triassic formed. Most of these sediments have a lot of quartz, the same as the rocks from which they came, and are therefore very hard to erode (Kent and Muttoni 2020). Therefore, the resulting red conglomerates and sandstones of the Buntsandstein stand out in the landscape, giving rise to mountains such as Adarra and Urdelar (Gipuzkoa) (Martínez-Torres 2008).

After the erosion process, from 230 to 20·Ma ago, the Thetis Sea flooded the territory by covering it under a thin sheet of water. Gradually, the sea retreated again and left in its wake a very flat coastal area formed by many shallow saltwater lagoons. The extremely arid conditions led to the deposition of red muds with evaporitic minerals such as gypsum and salt in local ponds. Consequently, the lagoons gradually evaporated. The remained clays are easily distinguishable by their intense reddish colour with greenish and ochre tones. We can see this set of Keuper rocks in Tolosa and Asteasu (Gipuzkoa), Gernika-Lumo, Bakio and Orduña (Biscay) and Murgia, Salinas de Añana, Arraia-Maeztu and Peñacerrada (Araba) (Frankovic et al. 2016) (in pink in Fig. 1). Those Keuper clays are very plastic and have a lower density than the rocks deposited on top of them in later stages. The weight of these more modern rocks exerts different load pressures on the clays, and these tend to escape upwards in the form of chimneys taking advantage of fractures or irregularities of the subsoil. When these chimneys meet a layer they cannot pass through, the clays accumulate below resulting in a large mushroom-shaped dough. Sometimes these chimneys manage to reach the surface (Bodego et al. 2018). In either case, the erosion of the terrain leaves us with a plan vision with rounded shapes. These ascent processes, which in some places continue today, occurred for many millions of years, mainly between the Cretaceous and the Miocene, thus, between 80 and 15·Ma ago (Roca et al. 2021). Usually, associated with these diapiric structures, green sub-volcanic rocks formed in the lower Jurassic appear. On their way up, the clays had enough capacity and strength to deform the surrounding rocks and drag them on their ascent (Cámara 2017).

Stage 3: 205–160 Ma ago

At this period, the movements of tectonic plates that had begun to crack Pangea ceased. At that moment, the sea began progressively to flood the continent. The subtropical climate facilitated the proliferation of life and the abundance of calcareous shells in those Jurassic waters. Its slow decanting on the seabed created a carbonated clay paste that today forms limestones and marls (in blue in Fig. 1). The set of sediments accumulated on those sea beds can be about 1100 m thick. We can see the best examples of these limestones in Aralar, Tolosa and Errezil (Gipuzkoa), the east bank of Oka estuary (Urdaibai Biosphere Reserve (BR); Biscay) or in the surroundings of Montoria (Araba) (Soler and José 1971; Duvernois et al. 1972). The most characteristic fossils of this time are ammonites, belemnites and sponges, but we can also find an important variety of algae, microfossils, shells of bivalves and crinoids. The Jurassic of Aralar also hides one of the most important copper mines in Basque Country: the Buruntzuzin mines in the Arritzaga Valley. Basques exploited scheelite, chalcopyrite, sphalerite, galena and malachite dikes formed by the filtration of hot fluids loaded with mineral elements through Jurassic sediments during the marine stage.

Stage 4: 160–121 Ma ago

Next come 50·Ma of calm, after which the tectonic plates began to move again and the sea level dropped considerably. From the mainland to the south came enormous deltas that turned the territory into a large plain where clay and small sandy lakes were interspersed. Some of the most spectacular specimens of snails and fossil fish in the Basque Country fossilized in those Purbeck-Weald ponds (Poyato-Ariza et al. 2000). These rocks give rise to soft reliefs such as the Igaratza area in Aralar (Gipuzkoa) or the northern slope of the Mendigana range (Araba). The sea gradually covered again those late Jurassic deltas resulting in great floodplains. The sands and clays deposited on those floodplains today form the mountains located south of Bilbao (Biscay).

Stage 5: 121–83 Ma ago

After a time of relative stability, the seabed began to crack again in response to the opening of the primitive Gulf of Biscay (Rat 1988; Van der Voo 1969). These movements resulted in an irregular and changing seabed with large raised blocks and high-deep sunken grooves delimited by major faults (Vergés et al. 2001; Jammes et al. 2009). The highest blocks got covered, and with the water temperature around 25 °C (Dercourt et al. 2000), little and large reefs formed on them. Those reefs were formed by an accumulation of corals of different types, microscopic organisms, molluscs, algae, sea urchins and above all, rudists (Damas-Mollá 2011). Thanks to its location, we can accurately rebuild the shape of those giant reefs (García-Mondéjar et al. 1996). These reefs, called Urgonian limestones, resulted in large thicknesses of light grey limestone easily recognizable in the landscape (Robles et al. 1988). Those limestones hosted the iron ores that helped to transform rural Bilbao into a busy industrial area. Today, they are priced as ornamental rocks and the main raw building material in the Basque Country (Velasco et al. 1994). Increased stretching, which also initiated submarine volcanism, caused some parts of the basin to sink too rapidly to be filled with sediments, leading to the creation of a deep marine depression. This is called the 'Flysch trough', because sediments reaching it accumulated in a conspicuous vertical alternation of resistant (conglomerates and/or sandstones) and soft (mudstones) beds, known as 'Flysch sequences' (e.g. Bodego et al. 2015).

Stage 6: 83–33 Ma ago

The Iberian Peninsula that had been drifting southwards the previous 165·Ma began moving northwards, toward Europe. Eventually, this caused a 'collision' with southern France, which created the Pyrenees, and deformed and uplifted the rocks deposited in the Basque–Cantabrian Basin. This inversion process developed slowly. In the beginning, only a few areas became emergent, mostly in the eastern Pyrenees, but the seas still covered most of the Basque–Cantabrian Zone (Saspiturry et al. 2019). Gradually, more and more areas moved to the surface. Contemporaneously, meteorological agents eroded uplifted terrains and transferred a fair proportion of the resulting detritus to the deep trough that accumulated as flysch sequences. These materials can be seen nowadays on the coast of the Gipuzkoa and Biscay provinces (in green in Fig. 1).

Stage 7: 33·Ma ago–Today

The inversion process advanced, and the former basin eventually transformed into the present-day hilly countryside. These mountains were (and still are) mainly sculptured by the action of rivers (del Val et al. 2015), groundwaters (Morales et al. 2010) and sea-level fluctuations (García-Artola et al. 2018).

Geoconservation in the Basque Country

The origins

Geoconservation in the Basque Country started with some descriptive works developed during the 1970–1980 period. For instance, Gómez-Tejedor (1980) already made clear references to the high value of the Basque geodiversity. Later, from 1983 to 1995, the City Councils of Araba, Biscay and Gipuzkoa promoted geosite inventories within a set of projects known as 'Geomorphological-Analytical Studies'. Those inventories included mapping and a brief description of geosites albeit using an untested methodology and achieving variable results. These inventories include about 1400 geosites with uneven geographical distribution. In Biscay, there were about 850 geosites inventoried (DFB 1990), in Gipuzkoa 320 (DFG 1991) and in Araba 230 (DFA 1995). Ten years later, in 2005, the Urdaibai BR developed its first geoheritage inventory boosted by an inspiration generated at the Spanish Geological Society Congress in 2004. In that geoconservation session, a young student named Luis Carcavilla presented his main arguments of what in 2007 would become his doctoral thesis (Carcavilla et al. 2007) and later would become the core of the Spanish method for inventories (García-Cortés et al. 2018).

Urdaibai Biosphere Reserve (BR): the Pilot Area

The United Nations Education, Science and Culture Organization (UNESCO) designated the territory of Urdaibai Biosphere Reserve (Biscay) in 1984 (Fig. 1). The Use and Management Action Plan of the Urdaibai BR and its Programme for Harmonization and Development of Socio-economic Activities establish the need to promote research and interpretation about the natural heritage, namely the transfer of knowledge, nature conservation, education and training. A recreational and tourism uses to provide opportunities and equipment for residents and visitors and to support rural development and the rational use of natural resources are also foreseen in these documents. In order to promote the geoheritage of the Urdaibai BR and in view of the strategic planning on geodiversity of the Autonomous Community of the Basque Country, the Basque administration decided to develop in 2010 a Geoconservation Strategy for Urdaibai BR (Mendia and Monge-Ganuzas 2011) as a pilot experience. The expectation was to use this model for the development of the overall Geoconservation Strategy of the Basque Country. The objectives of this strategy were the following: (1) to make a geosites inventory, (2) to plan and implement an institutional policy and a comprehensive management model of geoconservation, (3) to ensure the conservation and protection of geoheritage and geodiversity, (4) to promote education and training for the conservation and sustainable use of geoheritage, (5) to promote the sustainable use of geoheritage and geotourism and (6) to evaluate and monitor the proposed actions (Basque Government 2020).

To achieve the first objective, Mendia and Monge-Ganuzas (2011) followed the guidelines of Cendrero (1996) and Carcavilla et al. (2007) and inventoried 52 geosites (Table 1). These authors evaluated the inventoried geosites based on the scientific value and on the didactic-educational and tourist-recreational potential uses. The geosites fragility, vulnerability and risk of degradation were also evaluated. The majority of geosites in this inventory comprise Cretaceous and Quaternary materials and processes, which correspond to the most abounding materials in the area. Being an area highly covered by vegetation, the best outcrops and, consequently, the highest concentration of geosites are located on the coastal strip and on both sides of the central axis that represents the Oka estuary that crosses Urdaibai BR. It is worth noting some of the sites with the highest value: the black flysch; the Cretaceous marine carbonated platform facies which are very rich in fossils and diverse sedimentary structures; the coastal dynamics that shape the area; the Oka estuary, Laida and Laga beaches with high aesthetic value and obvious geomorphological value and significant stratigraphic/paleontological richness and variety; Mundaka sandy bar, an ephemeral geoheritage famous in the surfing community; and cape Matxitxako, a geographical reference with high scenic value. Some geosites are related to quaternary karstic processes affecting Lower Cretaceous rocks, which are elements of high scientific and didactic values and also tourist potential, such as pinnacles, dolines, sinkholes and cavities. Amongst all caves, we should give special mention to Santimamiñe cave designated as UNESCO's World Heritage in 2008 (Santimamiñe 2020). It is also worth mentioning the red limestones at Kantera Gorria, the 'Bilbao Red' ornamental rock used in many of the emblematic buildings of Bilbao and other European cities. In addition to its aesthetic value, it has an important geological interest (stratigraphic/paleontological and even tectonic and mineralogical).

Table 1 Inventory of geosites of Urdaibai Biosphere Reserve and their assessment (min: 1, max: 4) (from: Mendia et al., 2010). In bold, the geosites also inventoried at Basque Country scale

ID	Name	Scientific value	Educational or didactic value	Turistic or recreative value	Vulnerability and fragility
1	**Matxitxako black flysch**	3.0	2.8	2.7	1.0
2	**Matxitxako landslides**	2.8	3.0	2.5	1.5
3	**Olistolites at Aritzatxu beach**	2.4	2.8	2.7	2.3
4	Ancient abrasion platform at Bermeo (+30 m)	2.8	2.5	2.2	1.0
5	Errolatxu watershed	2.2	2.5	2.2	2.0
6	Ancient abrasion platform at Mundaka (+10 m)	1.4	2.0	1.0	1.2
7	Lumaquela of Ondartzape beach	2.4	2.3	2.2	2.3
8	**Corals and orbitolins at Mundaka**	2.6	2.5	2.7	2.5
9	Subvolcanic rocks associated with the diapir of Gernika	2.4	2.6	2.2	1.5
10	Sandindere island	2.2	2.3	1.8	1.8
11	San Pedro cave	1.6	2.0	1.7	1.5
12	Pinnacles of Atxapunta	2.0	2.3	1.0	1.3
13	Red clays of Axpe	1.8	1.0	1.5	1.5
14	Mape river	2.2	2.8	2.0	1.5
15	Malluku doline	1.4	1.3	1.0	1.0
16	Clays at Murueta quarry	1.6	2.3	2.0	1.3
17	Arrola sinkhole	1.8	2.3	1.0	1.3
18	Grey limestones at Forua quarry	1.2	1.3	1.3	1.0
19	Pillow lavas and pyroclastic breccias of Baldatika	2.2	2.0	1.7	1.0
20	Pillow lavas of Abaliz	2.2	2.5	1.3	1.0
21	Oka river gorge	2.0	1.5	1.3	2.3
22	Sandstones at Gorozika quarry	2.0	2.0	1.7	1.3
23	**K/P limit at Urrutxua**	2.4	2.8	2.3	2.0
24	Oka-Golako rivers	2.2	2.8	1.8	1.5
25	Gernika acuifer	2.0	1.8	1.5	2.3
26	Pyroclastic breccias of Ajangiz	2.2	2.0	2.0	1.3
27	**Uarka volcanic complex**	2.4	2.5	1.5	1.0
28	**Gernika anticline**	2.6	2.2	1.7	1.0
29	Aretxaga cave	2.8	2.8	1.3	1.3
30	Pinnacles of Ereñozar	2.8	2.5	1.7	1.0
31	Oma-Basondo dolines	2.8	2.8	2.2	1.0
32	Santimamiñe cave	3.0	2.5	2.7	1.0
33	Olalde spring	3.0	2.5	2.3	1.0
34	Doline of Bollar	1.8	2.0	1.8	1.0
35	**Red limestones at Kantera Gorria**	3.0	3.0	2.8	1.5
36	Argatxa-Oxinaga cave	2.2	1.5	1.2	1.3
37	Pinnacles of Atxarre	2.2	3.0	3.0	1.5
38	Polder of Anbeko	2.0	2.3	1.3	1.8
39	Jurassic limestone of Kanala	2.4	2.3	2.7	1.8
40	**Upper Oka estuary**	2.8	3.0	2.8	1.8
41	**Lower Oka estuary**	2.8	2.8	2.7	1.8
42	Laida beach and Mundaka sand bar	2.8	3.0	2.8	2.0
43	Carbonatate platform facies of Laida	1.8	1.8	1.5	1.8
44	Slope facies of Laida	2.8	2.8	2.7	1.0
45	Abrasion platform and boulder beach of Antxonazpia	2.0	1.5	1.2	1.3
46	**Laga beach**	2.8	3.0	2.8	2.3
47	Subvolcanic rocks associated to the diapir of Laga	2.0	2.8	2.2	1.0
48	**Asnarre cape complex**	3.0	2.8	2.2	1.5

Table 1 (continued)

ID	Name	Scientific value	Educational or didactic value	Turistic or recreative value	Vulnerability and fragility
49	**Ogoño vertical cliff**	2.6	2.5	2.0	1.0
50	**Elantxobe landslide**	2.2	2.8	2.3	2.5
51	Izaro island	3.0	2.3	1.7	1.0
52	Gaviota gas field	1.8	1.3	1.0	1.0

In addition to these geosite inventories, the Urdaibai BR distributed 28 interpretative panels along with its territory and published a guidebook describing its geosites and 13 geo-routes (Mendia et al. 2011), and 15 geotourism brochures focused on geological events, elements and processes (Baquedano et al. 2015). Due to the work done by Urdaibai BR, two private companies started to offer geotourism activities in the area (Naturtek 2020 and Ekobideak 2020).

Basque Coast UNESCO Global Geopark (UGGp): an International Reference

The Zumaia flysch outcrop in Gipuzkoa has been a world scientific reference for the last 50 years. The multidisciplinary research work carried out in the area has resulted in the designation of the two boundary stratotypes (GSSPs) of the Palaeocene (Schmitz et al. 2011). In addition, this stratigraphic section contains two of the best outcrops of the Cretaceous–Paleogene (Bernaola et al. 2006) and Palaeocene–Eocene (Borja et al. 2000) contacts. The geological relevance of this stretch of coastline was one of the main reasons for the designation of the Deba-Zumaia biotope, and it has been one of the pillars of the geotourism offer of the region. This link between scientific knowledge and institutional involvement has allowed ambitious policies of geoconservation, dissemination and geotourism under the conviction that geology can be an identifying element and an important local development engine. Later, in 2010, Basque Coast UGGp composing the towns of Zumaia, Deba and Mutriku incorporated into the Global Geoparks Network (Hilario and Carcavilla 2020). Here, protection (Biotope) and management (UGGp) of geoheritage complement each other to more effectively achieve the objectives set out in the strategic plans. The biotope provides the necessary legal basis for the protection of geoheritage and the regulation of uses, while the UGGp represents a more suitable platform for the development of management strategies, geotourism and local and international promotion of the territory (Hilario et al. 2013b).

Basque Coast UGGp (Fig. 1) covers an area of 90 km^2 and has a population of 19,700 inhabitants (Geoparkea 2020). We can divide this UGGp into two areas: (1) the cliffy coastal area where the flysch outcrops, composing 13 km of spectacular rock layers which in the manner of a large encyclopaedia, show us over 60·Ma of the history of the Earth. Geologists and visitors can walk along these cliffs or go on a boat trip and sail across time to discover, for example, the thin black layer that indicates the impact of a giant asteroid and the wholesale extinction of the dinosaurs about 65 Ma ago; and (2) the karstic inland, which is home to the largest number of caves in the whole region of Gipuzkoa. Amongst all the caves, we should give special mention to the Ekain cave declared by UNESCO as a World Heritage in 2008 (Basque Government 2020b).

The geosite inventory of the Basque Coast UGGp (Hilario et al. 2013a, 2013b) includes the geosites of highest scientific value, as well as those sites that stand out for their didactic potential or geotouristic appeal (Table 2). Moreover, the inventory is representative of the geology of the geopark. The methodology for the inventory of the 54 geosites was as follows: (1) analysis of the literature and previous work; (2) proposal of 10 geosites by geoexperts, obtaining a preliminary list of geosites; (3) analysis of the representativeness of the preliminary list; (4) proposal for a list of geosites; (5) layout of the inventory form to collect the data of each site and definition of valuation parameters (Table 2). This data sheet is based on the methodology used in the Urdaibai BR and Basque Country inventories, which in turn are compatible with the methodology proposed by IGME-CSIC (García-Cortés et al., 2018); (6) fieldwork and valuation of all proposed geosites; (7) preparation of the final inventory of the UGGp; and (8) analysis of data and basic proposal of recommendations for the UGGp geoheritage management.

Most of the geosites (67%) are located on the 13-km-long coastal strip. This fact should be expected if we take into account that we have a continuous outcrop with practically the entire time record. Hence, most of the stratigraphic and geomorphological coastal geosites are concentrated here. Due to the orientation of the layers, all geosites of the Cretaceous–Palaeocene–Eocene are located on the cliffs, where the continuous section emerges. On the contrary, in the continental part of the UGGp, the flysch gives rise to a relief covered with vegetation where we hardly find outcroppings. Geosites of the Quaternary period, karstic and coastal geomorphological, are predominant here. After the geosites related to the Quaternary period, the number of

Table 2 Inventory of geosites of Basque Country Global Geopark and their assessment (min: 1, max: 4) (from: Hilario et al., 2013a). In bold, the geosites also inventoried at Basque Country scale

ID	Geosite name	Scientific value	Educational or didactic value	Touristic or recreative value	Vulnerability and fragility
1	Triassic clays and ophites at Mutriku	2.3	2.0	1.8	1.0
2	Carbonated platform at Andutz	2.8	3.0	2.3	1.0
3	Conglomerates of Saturraran	3.5	2.0	3.1	1.0
4	Giant Ammonites at Mutriku	3.5	4.0	3.6	2.0
5	Syntectonic sediments at Mutriku	3.8	1.0	1.8	2.0
6	Septarias at Deba	3.8	2.0	3.7	2.0
7	Megalayer at Ondarbeltz	3.0	2.0	3.0	1.0
8	Black flysch at Aitzandi cape	3.8	1.0	2.2	1.0
9	Schistosity of the Kakuta Formation	2.3	2.0	1.7	1.0
10	Limestone Megabreccia of Deba	2.0	1.0	2.0	1.0
11	Paleokarst of Istiña	2.8	2.0	2.0	1.0
12	**Calcareous flysch at Sakoneta**	3.8	3.0	3.2	1.0
13	Sandy flysch at Arantzako portua	3.0	3.0	2.5	1.0
14	Maatrischtian flysch at Zumaia	4.0	3.0	3.6	1.0
15	**K/P limit at Zumaia**	4.0	3.0	3.6	2.0
16	Stratigraphic cyclicality at Zumaia	4.0	3.0	3.5	1.0
17	Stratotype of the base of the Selandian	4.0	2.0	3.5	1.0
18	Stratotype of the base of the Thanetian	4.0	2.0	3.5	2.0
19	**P/E limit at Itzurun**	4.0	3.0	3.5	1.0
20	Eocene flysch at Itzuruntxiki	3.3	3.0	3.5	1.0
21	**Icnofossils at Itzuruntxiki**	3.8	4.0	3.3	2.0
22	Duplex of San Telmo	3.0	2.0	3.4	1.0
23	Diaclases at Aizbeltz	2.8	2.0	2.5	1.0
24	Tip fault system at Mendata	3.0	3.0	3.1	1.0
25	Andutz fault	2.8	2.0	2.8	1.0
26	Lying fold at Aitzandi cape	3.5	2.0	2.5	1.0
27	Anticline at Sesiarte	3.3	3.0	2.7	1.0
28	**Itzurun beach geomorphological complex**	3.3	4.0	4.0	3.0
29	Boulder beach at Pikoteazpia	3.3	4.0	3.3	1.0
30	**Geomorphological complex at Sakoneta**	3.3	4.0	4.1	1.0
31	Dunes and marshes at Santiago beach	2.3	3.0	3.3	3.0
32	Saturraran beach	2.5	3.0	3.5	3.0
33	Erosion forms at Itzuruntxiki	2.8	4.0	3.6	1.0
34	Fallen Blocks at Marianton cape	3.0	4.0	3.6	1.0
35	**Litoral geomorphological ensemble of the Pikote landslides**	3.5	4.0	3.8	1.0
36	Slope Slide at Baratzazarrak	3.0	4.0	3.0	1.0
37	Abrasion platform at Algorri-Portutxiki	3.8	4.0	3.6	1.0
38	Cliffs at Txertudiko gabarlekua	3.0	4.0	3.4	1.0
39	Caves at Itzurun beach	3.3	4.0	3.8	1.0
40	Caves at Aitzuri cape	3.0	4.0	3.4	1.0
41	Hanging valley at Mendata	3.8	4.0	3.5	2.0
42	Deba estuary	2.0	3.0	2.8	3.0
43	Pinacular karst at Astigarribia	3.0	2.0	2.9	1.0
44	Polje at Olatz	3.5	3.0	3.1	3.0
45	Polje at Lastur	3.3	3.0	3.1	3.0
46	Dolines at Andutz mountain	3.0	3.0	2.5	2.0
47	Sasiola spring	2.0	3.0	1.9	3.0

Table 2 (continued)

ID	Geosite name	Scientific value	Educational or didactic value	Touristic or recreative value	Vulnerability and fragility
48	Lapiaz of Mount Arbil	2.5	3.0	3.0	1.0
49	Embedded river at Ugarteberri	3.3	3.0	3.2	3.0
50	Praileaitz cave	2.3	2.0	3.5	2.0
51	Karst Pinnacle of Salbatore	3.0	2.0	3.0	1.0
52	Quaternary site of Kiputz	3.3	3.0	3.8	2.0
53	Quarry of Lastur	3.0	3.0	3.0	1.0
54	Meander at Sasiola	2.5	4.0	2.5	1.0

geosites relative to the Lower Cretaceous (25%) stands out, as expected from the geographical distribution and complexity of rocks of this age, covering approximately 75% of the territory of the UGGp. From a thematic point of view, the importance of stratigraphic and paleontological geosites is also evident, adding between the two up to more than half of the registration (50%). These geosites have been the most studied in the geopark. On the thematic distribution map of the UGGp (Geoparkea 2020), it can be seen how the geosites of karstic nature are located over the reef limestones of the Lower Cretaceous that form the mountains of the inland. Geosites of a stratigraphic-paleontological nature are mostly located on the coastal cliffs, although some can be found inland. Coastal geomorphological geosites are logically located on the coast.

Priority objectives that are reflected in the multiple initiatives carried out in recent years are to promote the geological values of the UGGp and to help researchers, mainly, in the protected biotope environment (Hilario et al. 2011). These include the work done by interpretation centres to design didactic materials, a wide range of guided tours and a large-format photographic book 'Flysch Algorri Mendata' (Hilario and Carballo 2010) and the documentary 'Flysch, the whisper of the rocks' (Geoparkea 2020b). Of particular interest for geological interpretation are the publication of the guidebook 'The Biotope of the Flysch' and the design of the geo-routes (Hilario 2012). The geo-routes network is composed of four themed trails and a cross path that serves as a link between the different geo-routes. In total, 20 km of trails have been renovated. Moreover, there are 38 interpretation points. The UGGp have produced interpretation panels in the five most emblematic viewpoints along 6 km of coastline and on different geo-routes, published a guidebook and arranged a web page (Geoparkea 2020). The rapid proliferation of smartphones opens up a new world of possibilities for the interpretation of geoheritage. Therefore, all the teaching material generated for the guide has been adapted, so visitors can download it from the website by reading QR codes located on all the plates and panels of the geo-routes. Tourism offices and interpretation centres are equipped with a free Wi-Fi system to allow visitors the download of these resources.

The Basque Geodiversity Strategy 2020

During the last two decades, Spain has witnessed an accelerated evolution in relation to geoconservation (Díaz-Martínez et al. 2014). The consideration of geoheritage, not only as a scientific or educational resource, but also as an economic resource of interest for sustainable development strategies (geotourism) on a given territory, is contributing decisively to this trend, especially, in protected natural areas (Gordon 2018).

As we stated in the introductory section, the Basque Country has unique competences in environmental issues, including geoheritage and geodiversity management, so its government decided to implement a Basque Geodiversity Strategy (BGE2020) in order to comply with the mandate established by the Spanish legislation.

Given that the terms geodiversity and geoheritage are relatively new in the context of environmental and sustainable development policies, the Basque Country assumed with the BGE2020 (Basque Government 2020c), the mandate to establish its framework instrument. This instrument collects the basis for the Basque geoheritage and geodiversity management. It defines the strategies, programmes and actions necessary to coordinate the different multidisciplinary actors involved in such management, both administrations and public institutions with competences in this field (Basque Government, Provincial Councils, Municipalities, Consortia, Commonwealths, Tourism Offices, Rural Development Agencies, etc.), as well as private bodies, associations or NGOs.

In this sense, the Basque Country proposes the BGE2020 with the aim of balancing the development of the territory with the value and conservation of natural resources, in this case, geological. In order to ensure participation in the discussion and approval of the document prepared, the Basque Government carried out a participative process with the government bodies, institutions, companies and environmental organizations, and information campaigns among citizens. In 2014, by order of the environment and territorial policy counsellor, the Basque Government passed the BGE2020. This strategy includes the current geosite inventory of the Basque Country (Arana and Monge-Ganuzas 2013, 2015, 2017; Monge-Ganuzas et al. 2011, 2015, 2019). The Basque Government carried out this strategy with the following objectives: (1) identify and describe the geoheritage of the Basque Country; (2) obtain a systematized inventory that characterizes the geological sites of Basque Country; (3) delimit and map these places and incorporate the geographical information obtained into the GIS (Basque Government, 2020c); (4) establish a geosites assessment of the selected from a scientific, didactic-educational and tourist-recreational point of view that serves to prioritize protection or use measures; (5) analyse the fragility, vulnerability and risk of degradation of the identified geological heritage; and (6) define a geodiversity strategy for the conservation, value and public use of this heritage. To achieve these objectives, BGE2020 proposes 4 strategic objectives, 9 operative objectives, 22 operative sub-objectives and 45 actions summarized in Table 3. Its evaluation will provide a regular monitoring report assessing its degree of compliance and will propose, if needed, corrective measures. From an operational point of view, the Basque Directorate of Natural Environment is responsible for the management and monitoring process. Evaluation reports will be integrated into the existing coordination management structures.

Basque Geosite Inventory

The Basque geosite inventory (Mendia et al. 2013) identifies, describes and evaluates 150 geosites (Table 4; Figs. 1, 2, and 3). The procedure used in this inventory was based on the methodology designed for the Urdaibai BR Inventory (Mendia et al. 2010), with some adaptations for a broader scale. These authors mainly identified in situ elements, although some geosites correspond to paleontological sites from where fossils were collected and moved to museums or to the Faculty of Science and Technology of the University of the Basque Country.

The typology of geosites corresponds mostly to areas of different sizes that have been delimited, mapped and integrated into a GIS (Basque Government 2020d), following the limits of the selected outcroppings. For structural type and cartographic scale geosites, such as large bends or faults, the authors delimited the best observable part of each element. In the particular case of paleontological deposits, they delimited the area corresponding to the deposit, but this information is not available to the public in order to avoid plunder. In some geosites relative to the Quaternary period, active processes may vary over a very short, even seasonal, timeline, such as many geosites related to coastal dynamics (e.g. a beach or sandbars). The selection process of the 150 geosites has been quite laborious, and the collaboration of geoexperts of the Geology Section of the University of the Basque Country who have contributed their knowledge in various phases of the work has been essential.

The authors carried out the inventory in three phases: (1) a bibliographic compilation; (2) a selection process; and (3) a field recognition and valuation. The bibliographical documentary collection has generated a database with almost 1000 references and a geological synthesis. From this collection, the authors obtained from previous inventories a preliminary list of 1400 possible geosites. The basic criterion to select the geosites was the representativeness of the geological record and the processes that took place within Basque Country.

First, the authors sorted the 1400 geosites according to geological disciplines (stratigraphic-sedimentological, paleontological, hydrogeological, mineralogical, petrological, tectonic-structural and geomorphological), obtaining between 50 and 150 geosites per discipline. The authors grouped the geosites present in more than one of the previous geosite directory into a preferred list, leaving the rest in a second list. They provided this double list to each thematic geoexpert for study. In addition, each thematic geoexpert proposed new geosites of interest in their specialty. Once the authors studied the two lists and personal contributions, each geoexpert provided a prioritized list. The criteria established for this first selection in order to identify the geosites due to their scientific value were representativeness and uniqueness. As a result, each thematic expert provided between 20 and 30 geosites sorted according to their assessment, obtaining approximately 300 geosites. This list was then sorted and reclassified according to chronostratigraphy, and the value rate of each geosite to verify that the overall objective of the inventory ensures the representativeness of the geology of the Basque Country in the sense indicated by Elízaga and Palacio (1996) and Carcavilla et al. (2007).

After the classification carried out, the authors again reviewed the final list of geosites and compared it with the initial one to verify that the 'representativeness' criterion was guaranteed. In case that various listed geosites represented the same geological theme, the authors selected the one that presented the highest assessment in the ranking of the geoexperts or the one that was included in more than one previous geosites directories or the one proposed by more than one geoexpert. In this way, the authors get a list of approximately 150 relevant geosites and another list of other 150 of less value.

At the same time, the authors established the valuation criteria based on previous work in Urdaibai BR (Mendia et al. 2010) which establishes three independent valuation criteria: intrinsic value, didactic-educational potential and tourist-recreational potential. A bibliometric index, calculated by identifying the existing publications in the bibliography in

Table 3 Objectives and actions of the Basque strategy for geoconservation 2020 (from: www.euskadi.eus)

Strategic and operative objectives	Actions
1. Definition of an institutional policy and an integral management model of geodiversity and geoheritage	
1.1. Establish an adequate legal and institutional framework for the management of geodiversity	
1.1.1. Adapt the legal framework and normative for the management	1. Approve the Inventory of the Basque Geosites establishing regulation for its conservation, use and enhancement
1.1.2. Create an adequate administrative framework for the proper management	2. Incorporate the conservation and management of geodiversity and geoheritage among the topics of the Environmental Department
1.1.3. Keep the Basque Inventory of geosites updated	3. Establish a technical commission in charge of analyzing the proposals for inclusion and exclusion of geosites or modifications and establish the regulatory protocol for the inclusion/exclusion of geosites or their modifications
1.2. Ensure the integrated management of geodiversity through inter-administrative coordination and the representation of the agents involved in decision making	
1.2.1. Adapt and strengthen inter-administrative coordination between the institutions with competences in geodiversity and geoheritage	4. Use existing channels of information, cooperation and coordination between the different administrations, agents and bodies with direct and indirect competences on geodiversity
	5. Coordinate the Geodiversity Strategy with the rest of the existing Basque strategies
	6. Develop protocols to coordinate administrative procedures related to environmental prevention, projects research, conservation projects, etc., to integrate the conservation of geodiversity
1.2.2. Encourage public and social participation in the management of geodiversity and geoheritage	7. Prepare a directory of social and institutional agents related to geodiversity and geoheritage management
	8. Develop communication forums on the management of geodiversity and geoheritage
2. Guarantee the conservation and protection of the basque geoheritage	
2.1. Reinforce the conservation of geoheritage through its incorporation into territorial planning instruments	
2.1.1. Include geosites in territorial and urban planning processes	9. Incorporate the geosites into the management instruments of the territory of the Basque Country as elements to protect, with guidelines to ensure their conservation and protection
2.1.2. Include geosites in the decision making processes regarding environmental prevention plans or projects	10. The public administrations will take into account the protection of the inventoried geosites in the procedures of approval, authorization or control of plans, programs or projects that may have negative effects on such geosites
2.1.3. Include geosites in environmental planning of Protected Areas	11. Incorporate effective conservation and management of Geosites in the management documents of the Protected Areas, establishing the criteria and determinations for its conservation, protection, restoration and use
2.1.4. Define, for the Basque Country, the contents in geodiversity and geoheritage to be developed through the planning and management instruments defined by Law 42/2007, December 13, Natural Heritage and the Biodiversity	12. Analyze the geological contexts of the geroheritage of the Basque Country to determine its fit with units and geological contexts defined in Annex VIII of Law 42/2007 or for propose them as Global Geosites
2.2. Define practical tools for active conservation of geoheritage	
2.2.1. Develop actions for conservation and management geoheritage	13. Define monitoring needs and develop an evaluation system
	14. Carry out studies to define geoindicators that allow monitoring the state of the geoheritage and geodiversity, with special emphasis on ecosystems of special interest or of high vulnerability
2.2.2. Evaluate the incidence of climate change in the Basque geodiversity and geoheritage	15. Carry out a risk assessment and diagnosis on the geodiversity and geoheritage derived from change climate and track it through existing data on alteration of geological processes
2.2.3. Establish agreements or other management models that guarantee the conservation of geodiversity and geoheritage	16. Draw up collaboration agreements or stewardship agreements with owners or agents in order to guarantee the protection of geodiversity and geoheritage

Table 3 (continued)

Strategic and operative objectives	Actions
2.2.4. Enter geodiversity and geoheritage in the information and management administrative systems of the Basque Environment Department	17. Incorporate geosites into the tools and applications of the Basque Environment Department
	18. Integrate information related to geodiversity and geoheritage among the communication activities of the Environment Department
3. Promote the sustainable use of the geodiversity and the promotion of geotourism	
3.1. Strengthen geodiversity in sustainable development policies, programs and strategies	
3.1.1 Incorporate the Basque geodiversity and geoheritage as a touristic product	19. Define and promote a specific tourism subsegment (geotourism) and incorporate it into rural and nature tourism activities
	20. Take advantage of the international projection of the Basque Coast Global Geopark to publicize the rest of the geotourism initiatives of the Basque Country
3.1.2. Improve institutional coordination to reinforce the role of geodiversity and geoheritage in rural development strategies	21. Coordinate actions to enhance the geoheritage and geodiversity of the Basque Country with those provided by the Rural Development Plans
	22. Promote the role of geodiversity and geoheritage in rural development projects
	23. Support and participate institutionally in projects with European funding that take as their main axis the enhancement of geodiversity and geoheritage
	24. Carry out formative and informative workshops to show projects and experiences that prove the usefulness of geodiversity and geoheritage in rural development
3.1.3. Consolidate the image of geodiversity and geoheritage as a commercial resource in research dissemination, training, promotion and support strategies for the commercialization of local products and services	25. Identify current and potential business niches for local geoproducts
	26. Carry out awareness and communication campaigns as well as training courses for companies on the value of geodiversity and geoheritage as a commercial product
3.2. Consolidate an institutional geotourism offer	
3.2.1. Define and adapt specific equipment for interpretation and enhancement of geodiversity and geoheritage	27. Define a homogeneous model for all actions related to geodiversity referred to by its disclosure: image, explanatory panel formats, brochures, materials, etc
	28. Review and, where appropriate, increase the information regarding geodiversity and geoheritage of the exhibitions of the interpretation centers
	29. Enable specific spaces in existing centers for the exposition of the most significant aspects associated with the geological domains of the Basque Country
	30. Adapt infrastructures and equipment for geointerpretation in the field and take advantage of the existing or potential network of trails and routes as the basis for improving knowledge of geoheritage and geodiversity, providing them with interpretive resources
	31. Prepare an inventory of public and private collections, museums and classroom museums of minerals, rocks and existing fossils and promote its use as an instrument to disseminate the geoheritage of the Basque Country
Objective 4: promote education and training for conservation and sustainable use of geodiversity and geoheritage, as well as its international promotion	
4.1. Incorporate geodiversity into environmental education policies and strategies	
4.1.1. Generate an appropriate institutional framework	32. Incorporate aspects related to geodiversity and geoheritage in the Education Strategy for Sustainability

Table 3 (continued)

Strategic and operative objectives	Actions
4.1.2. Encourage the information, awareness, and involvement of the educational community in the conservation of geodiversity and geoheritage	33. Publish informative articles dedicated to geodiversity and geoheritage
	34. Promote the development of specific campaigns within the education programs for sustainability, aimed at the interpretation and knowledge of geodiversity and geoheritage at the different pedagogical levels of regulated education
	35. Develop specific courses for educators, with teaching units related to knowledge of the physical environment, geodiversity and geoheritage
	36. Incorporate education actions on geodiversity and geoheritage in non-regulated educational centers
	37. Define specific training courses on geoconservation for public (personal interpretation centers) and private (hotels, rural tourism, etc.) agents
4.1.3. Develop materials, tools and events aimed at the dissemination and diffusion of geodiversity	38. Develop tools, supported by new technologies that facilitate the dissemination and knowledge of the Basque geoheritage and geodiversity
	39. Prepare a Guide about Basque geodiversity
	40. Edit teaching materials and resources, with proposals of georoutes through the Basque Country and facilitate its distribution in educational centers
	41. Organize specific conferences, congresses and forums on the subject of geodiversity in the most emblematic geological spaces of the Basque Country
4.2. Improve knowledge of the geodiversity of the basque country through scientific research	
4.2.1. Incorporate geodiversity and geoheritage into Basque science policy priorities	42. Define research lines for geodiversity and geoheritage
	43. Incorporate the studies about geodiversity and geoheritage into the Basque grant lines
4.3. Strengthen the presence of the Basque Country in international geoconservationist forums	
4.3.1. Promote education and training for conservation and sustainable use of geodiversity and geoheritage, as well as its international dissemination	44. Increase the presence of the Basque Country in international organizations and promote international study, conservation and dissemination networks about geoheritage
	45. Consolidate Basque Coast Global Geopark and Urdaibai Biosphere Reserve as practical laboratories for the development of actions related to geodiversity and geoheritage

relation to each geosite and calculating the arithmetic mean in relation to the number of geosites analyzed by adding a correction factor relative to the impact index of each publication, was included in the design of the final assessment (Carcavilla et al. 2007; Mendia et al. 2010).

Subsequently, the authors carried out the third phase of the work, the recognition of the geosites in the field. They visited the 150 geosites and some on the secondary list, resulting in some of them being dismissed for a variety of reasons, such as poor outcrop conditions and poor observational conditions. Once chosen, the final 150 points were valued again. Likewise, the authors plotted their mapping area and incorporated it into the GIS database. The rest of the fieldwork has consisted of data collection, such as access, the optimal point of observation and photo documentation.

All the information contained in each geosite was included in a descriptive document that included information regarding its location and access, the optimal point of observation, the description of the geological elements found, detail schemes and photos, specific bibliography and related geosites. The document also contains qualitative and quantitative assessment tables, with a description of the geological highlights, and values of the three valuation parameters plus information regarding their vulnerability and fragility. The authors added also information on land-use management and proposals for action. A summarized informative document for each site can be downloaded on the website of the Basque Government (2020e).

The Basque Country has a high geodiversity represented by its geological materials, structures and processes. Some of them have international importance such as the

Table 4 Inventory of geosites of Basque Country and their assessment (min: 1, max: 4) (from: Mendia et al., 2013)

ID	Geosite name	Scientific value	Educational or didactic value	Touristic or recreative value	Vulnerability and fragility
1	Paleozoic marine life remains from Gaztelubehekoa-Gaztelugoikoa	3.0	3.5	3.6	3.0
2	Paleozoic continental plant remains from Burkalekogaina	3.0	3.5	3.6	3.0
3	Metamorphic rocks in contact with the Aia granite	3.3	2.4	3.0	1.0
4	Hybrid facies of Aia granite	3.8	2.8	3.0	2.0
5	Buntsandstein in Leungo Harkaitzak	2.5	3.0	3.2	1.0
6	Jointed crests of the Buntsandstein and block fall on Adarra mountain	3.5	2.6	2.3	1.0
7	Clays and ophites from Bakio	2.5	2.8	3.2	4.0
8	Urbia Depression	3.3	2.6	3.2	1.0
9	Jurassic-Urgonian section of Arritzaga ravine	3.5	2.4	2.8	2.0
10	Spring of the Peñacerrada Mill	1.8	2.4	2.3	3.0
11	Black Weald Series in Artea	3.0	2.0	2.0	3.0
12	Igoroin ravine	3.3	3.4	3.1	1.0
13	Gernika anticline	3.3	3.2	3.6	1.0
14	Asnarre cape complex	3.8	3.0	3.6	3.0
15	Red limestones of Kantera Gorria	4.0	3.4	3.4	2.0
16	Carbonated shelf margin of Ranero	3.5	3.0	3.2	1.0
17	Olistolites from Aldeacueva	2.8	2.2	2.4	1.0
18	Carbonated ramp of Peñalba	3.0	2.6	2.7	1.0
19	Limestones and ridges of Mount Anboto	3.5	3.8	3.6	1.0
20	La Garbea sandstones	3.5	2.4	2.2	2.0
21	Limestones of Egino	3.0	3.2	3.1	1.0
22	Matxitxako Black Flysch	3.0	3.2	3.4	2.0
23	Black Flysch of the Seven Beaches (Kardal-Saturraran)	3.3	3.0	3.4	3.0
24	Armintza Black Flysch	3.3	3.0	2.9	2.0
25	Alkolea cape Black Flysch	4.0	2.4	2.6	1.0
26	El Castillito section (Urtikoetxe cape)	3.5	2.2	2.8	2.0
27	Calcareous flysch at Sakoneta	3.3	3.4	3.5	4.0
28	Sandy Flysch of the Upper Cretaceous of Deba-Zumaia	3.8	3.4	3.6	3.0
29	Subijana limestones	3.5	3.2	2.6	1.0
30	San Tirso bonnet	3.0	2.6	2.9	1.0
31	Marls of the Upper Cretaceous in Galarreta	2.0	2.2	2.2	2.0
32	Olistolites at Aritzatxu beach	3.0	3.0	3.3	2.0
33	Upper Cretaceous of the port of Azazeta	2.8	1.8	1.5	1.0
34	Limestones and basalts of Larrano	3.0	2.2	2.6	1.0
35	Pillow lavas of Meñakoz	3.5	2.2	3.0	2.0
36	Basalts at Fruiz	3.5	3.0	2.7	3.0
37	Pillow lavas of Soraluze	3.0	3.0	2.9	1.0
38	Dike of Eibar	3.0	2.6	2.7	1.0
39	Sill of Elgoibar	3.8	2.6	2.7	2.0
40	Gabbros from the Urretxu quarry	3.3	3.2	2.7	3.0
41	Karakate volcanic section	3.5	3.0	2.9	1.0
42	Uarka volcanic complex	3.5	3.0	4.0	1.0
43	K/P limit at Zumaia	3.8	3.8	3.9	3.0
44	K/P limit at Sopelana	3.5	3.0	3.4	4.0
45	Palaeocene/Eocene limit at Itzurun	4.0	3.6	3.9	4.0
46	Stratigraphic series of the Sobrón canyon	3.3	2.8	2.9	2.0
47	Okina Gorge section	3.0	3.3	2.4	1.0
48	P/E limit at Zumaia	3.8	3.0	3.4	4.0

Table 4 (continued)

ID	Geosite name	Scientific value	Educational or didactic value	Touristic or recreative value	Vulnerability and fragility
49	Eocene of Gorrondatxe (GSSP)	4.0	3.4	3.3	2.0
50	Jaizkibel Eocene Flysch at cape Arando	3.0	3.0	3.2	4.0
51	Lacustrine limestone of the Loza synclinal	3.0	1.8	2.1	2.0
52	Eocene limestones from Mirutegi (Urbasa)	3.3	2.0	2.4	1.0
53	Kripan conglomerates	3.3	3.0	3.3	2.0
54	Pobes conglomerates	2.8	2.0	2.3	1.0
55	Lapuebla river series	3.0	3.0	3.2	1.0
56	Itxina karst	3.3	2.8	2.6	1.0
57	Arbieto doline	2.8	2.6	3.8	2.0
58	Badaia doline field	3.3	2.4	2.2	1.0
59	Karst in needles at Peñas Blancas	3.0	2.8	2.8	1.0
60	Olatz polje	2.8	3.0	3.2	3.0
61	Indusi Karst	3.3	3.4	2.6	2.0
62	Closed valley and dolines of Oma and sinkhole of Bolunzulo	2.8	3.2	3.4	3.0
63	Pinnacle karst at Deba	3.0	3.4	3.4	4.0
64	Pozalagua cave	4.0	3.6	3.4	4.0
65	Arrikrutz cave	3.5	4.0	3.6	4.0
66	Goikoetxe cave	3.8	2.0	2.8	4.0
67	El Carlista sinkhole	3.5	2.2	3.4	4.0
68	La Leze cave	3.8	3.2	3.2	2.0
69	Nerbioi cascade at Delika canyon	3.3	3.6	2.4	2.0
70	Gujuli cascade	3.5	3.6	2.9	2.0
71	Oiartzun river terraces	2.8	2.8	2.9	4.0
72	Fluvial terraces at Baños de Ebro	3.0	2.8	3.1	3.0
73	Iraeta meander	3.0	3.4	3.0	2.0
74	Travertines at Ocio	3.0	2.8	2.6	3.0
75	Purón river gorge	2.8	2.4	2.9	3.0
76	La Gaviota gas field	3.0	2.6	2.2	1.0
77	River valleys of Jaizkibel	3.3	2.2	2.7	3.0
78	Arreo Lake	3.8	3.0	3.2	3.0
79	Wetlands and quaternary materials at Salburu	3.0	3.0	3.0	4.0
80	Laguardia lakes	2.5	3.2	3.7	3.0
81	Gesaltza sink	3.5	2.4	2.9	3.0
82	Springs and galleries of the Arantzazu canyon	3.3	3.4	3.6	2.0
83	Zazpiturrieta emergence	3.0	2.2	2.8	2.0
84	Sulfur springs of Aretxabaleta and Eskoriatza	2.5	1.8	2.1	2.0
85	Getaria Mouse Tombolo	3.3	3.6	3.8	1.0
86	Sobrón hot springs	3.0	2.6	2.6	2.0
87	Glacier valley and moraines of Arritzaga	3.5	3.0	3.1	1.0
88	San Juan de Gaztelugatxe tombolo	3.8	3.4	3.6	2.0
89	Donostia Bay	2.5	3.2	3.2	4.0
90	La Galea-Barrika ancient abrasion platform	3.3	2.8	3.2	3.0
91	Astondo fossil dunes	3.3	3.0	3.6	3.0
92	Laga beach	3.5	2.8	4.0	4.0
93	Barrika sandbanks	3.0	2.4	3.2	2.0
94	La Arena beach and dunes	2.3	3.2	3.4	4.0
95	Quaternary paleontological site at Kiputz	3.8	2.8	2.7	3.0
96	Cemented beaches of Gorrondatxe and Tunelboca	3.5	3.2	3.7	4.0

Table 4 (continued)

ID	Geosite name	Scientific value	Educational or didactic value	Touristic or recreative value	Vulnerability and fragility
97	Lower Oka estuary	3.8	3.6	3.8	4.0
98	Upper Oka estuary	3.5	3.6	3.8	3.0
99	Structural cliffs of Pasaia	3.3	3.4	3.6	4.0
100	Ogoño vertical cliff	3.5	3.4	3.8	1.0
101	Geomorphological complex at Sakoneta	3.5	4.0	4.0	2.0
102	Litoral geomorphological ensemble of the Pikote landslides	3.5	4.0	4.0	2.0
103	Itzurun beach geomorphological complex	3.0	4.0	4.0	4.0
104	Elantxobe landslide	2.5	3.0	3.4	3.0
105	Matxitxako landslides	3.0	3.6	3.4	2.0
106	Arritzaga copper mines	2.8	2.0	2.6	3.0
107	Karrantza colluviums	3.0	3.0	3.3	1.0
108	Nivation cirque of Alluitz mountain	3.5	4.0	3.7	1.0
109	Pico del Fraile pinnacle	3.3	3.0	2.8	1.0
110	Pinnacles at Markinez	3.5	3.2	2.6	1.0
111	Peña Carrias ridge and monoliths	3.3	3.4	3.1	1.0
112	Txindoki ridges and limestones	3.3	3.4	3.4	1.0
113	Las Muelas de Campezo sloping relief	3.0	3.4	3.0	1.0
114	Structural modeling (table) of Orduña	3.3	3.6	3.4	1.0
115	Erosive forms at Labetxu (Jaizkibel)	4.0	3.0	3.1	2.0
116	Añana diapir	3.0	2.4	2.8	1.0
117	Galea point synclinal fold	3.3	1.6	2.8	1.0
118	Barrika and Txitxarropunta folds	4.0	3.0	4.0	1.0
119	Folding at Aitzandi cape	3.0	2.6	3.2	1.0
120	Ataun dome	3.8	2.8	3.0	1.0
121	Valderejo perianticline closure	3.3	3.4	3.2	1.0
122	Anticline at Ocio	3.3	2.4	2.3	1.0
123	South Pyrenean frontal overthrust at Las Conchas de Haro	3.8	2.8	3.2	1.0
124	K/P limit at Urrutxua	3.5	3.6	3.6	3.0
125	Cabo Billano complex	3.0	2.2	2.7	1.0
126	Hanging syncline (inverted relief) of Ernio mountain	3.3	3.2	2.7	1.0
127	Septarias of Deba	3.3	3.5	3.7	4.0
128	Mammals of Zambrana	3.8	3.5	3.4	4.0
129	Amber deposits at Peñacerrada	3.5	3.5	3.4	4.0
130	Icnites of tertiary mammals at Salinas de Añana	3.5	3.8	3.4	4.0
131	Fossil fishes at Zeanuri	3.8	3.3	3.1	4.0
132	Numulites at Punta Galea-Tunelboca	3.3	2.6	3.2	3.0
133	Ammonites and corals at San Roque	3.0	2.2	2.7	1.0
134	Corals and orbitolins at Mundaka	2.8	3.2	3.7	4.0
135	Ichnofossils of the Eocene flysch of Zumaia-Getaria	3.5	2.4	3.2	3.0
136	Paramoudras of Jaizkibel	3.8	2.8	3.0	4.0
137	Fauna and marsh flora at Murgia	3.8	3.3	3.1	2.0
138	Dolomites at Ranero	4.0	3.4	3.2	1.0
139	Arditurri Mines	3.8	3.4	3.4	1.0
140	Open pit and inner mine at Bodovalle	3.5	3.0	3.1	1.0
141	Iron veins at Laia-El Sauco (Galdames)	3.3	3.2	2.9	1.0
142	Salt flats at Añana	3.3	3.6	3.3	2.0
143	Gipsum mines at Paul	2.8	2.4	2.3	1.0
144	Barite at Pozalagua	3.5	2.6	2.9	4.0

Table 4 (continued)

ID	Geosite name	Scientific value	Educational or didactic value	Touristic or recreative value	Vulnerability and fragility
145	Ángela mine at Matienzo	2.5	2.6	2.8	1.0
146	Spatic calcite from the Valnera fault	4.0	2.4	2.4	3.0
147	Mutiloa dome mining complex (Troya mines)	2.5	2.4	2.0	1.0
148	Open-pit mining and underground mine of Malaespera	3.0	1.6	2.4	3.0
149	La Reineta-La Arboleda open pit mining	3.0	2.6	3.1	3.0
150	Asphalt of Maeztu	3.3	2.0	2.1	3.0

Cretaceous/Paleogene boundary of Zumaia, the stratotypes of the Palaeocene of Zumaia and the Eocene of Gorrondatxe (Biscay), the iron mineralization of Gallarta (Biscay) or the Pb–Zn mines of Siete Puertas and La Troya (Gipuzkoa). An analysis of the variety and frequency of geosites considering a chronostratigraphic criterion and taking the periods represented as a reference results in a clear majority of geosites corresponding to the Quaternary and Cretaceous geological periods. This is because these geosites reflect the reality of the geological record, as outcrops relative to the Cretaceous period occupy just over 70% of the Basque Country. As for the abundance of geosites of the Quaternary period, it can be noted that they include a wide variety of geomorphological traits such as endokartic and exokartic processes widely represented in Basque Country as well as those related to coastal modelling, both constituting 50% of geosites representative of the Quaternary period. The rest corresponds to river modelling, structural reliefs and slippages. On the other hand, taking into account the geological discipline in which geosites stand out, there are a greater number of geosites with geomorphological and stratigraphic interest, as it could be expected. However, there is a good representation of other geological disciplines as well.

The geosites located on the coast are protected by the Spanish Coastal Law (Law 22/1988 of 28 July) and by the Sectoral Territorial Plan for the Protection and Management of the Littoral (Decree 43/2007 of 13 March), and the ones located in protected areas are subject to environmental regulation. Of the 150 inventoried geosites, 97 are located in Basque protected areas, but unfortunately, they are not yet included in the management plans, although Basque environmental administration planned their inclusion at the time of their review. Nowadays, the Deba-Zumaia Littoral Biotope is the only protected area in which geology is the main protagonist, and so far, Basque cultural legislation only protects some of the paleontological sites. Therefore, the management of these elements which can be at times geological, cultural, geological of cultural interest or cultural of geological interest should be agreed and coordinated. As we will see in the next section, the Basque Country has opted for the land-use legislative instruments to ensure the protection and good management of inventoried geosites.

Land-Use Planning Legislation: the Legislative Instrument for Geoheritage Protection

In 2015, the Basque Government initiated the revision of the Basque Land Management Guidelines (LMGs) in accordance with the Law 4/1990. The Basque Government approved the Territorial Planning Guidelines by Decree 128/2019.

The Land-use Planning Act 4/1990 of the Basque Country defines cascading planning as a guiding principle. On this principle, territorial planning policy stands and forms the corpus of territorial planning. LMGs are the instrument that defines the Basque Territorial Strategy by following the main guidelines for the management of Basque territory, giving coherence to the different sectoral and local decisions. LMGs develop in more defined instruments either for a specific theme — Sectoral Territorial Plans (STPs) — or for a specific Functional Area — Partial Territorial Plans (PTPs). In turn, STPs and PTPs serve as a guide for the drafting of the General Urban Planning Plans (GUPPs) that each municipality drafts. These instruments have a cascading hierarchy: LMGs prevail over PTPs and STPs, and both, over the GUPPs.

The new Decree 128/2019, of July 30, enhances LMGs for the non-urban environment. It zones the territory into homogeneous spaces, each defined according to their inherent best use, and sorts them into six land categories among which is Special Protection. On top of these, overlapping conditions such as natural risk and climate change, and green infrastructure, further restrict the uses established for each zone based on a special interest. LMGs also list land uses. Finally, a matrix which crosses land categories with uses determines the final code for regulation of each zone: encouraged, permitted or prohibited use.

Special Protection category applies to all valuable ecological, cultural or landscape elements, and the declared 150 Basque geosites are specifically included, among other heritage. The general criterion for these areas is to limit anthropic intervention, and if the area hosts any land use,

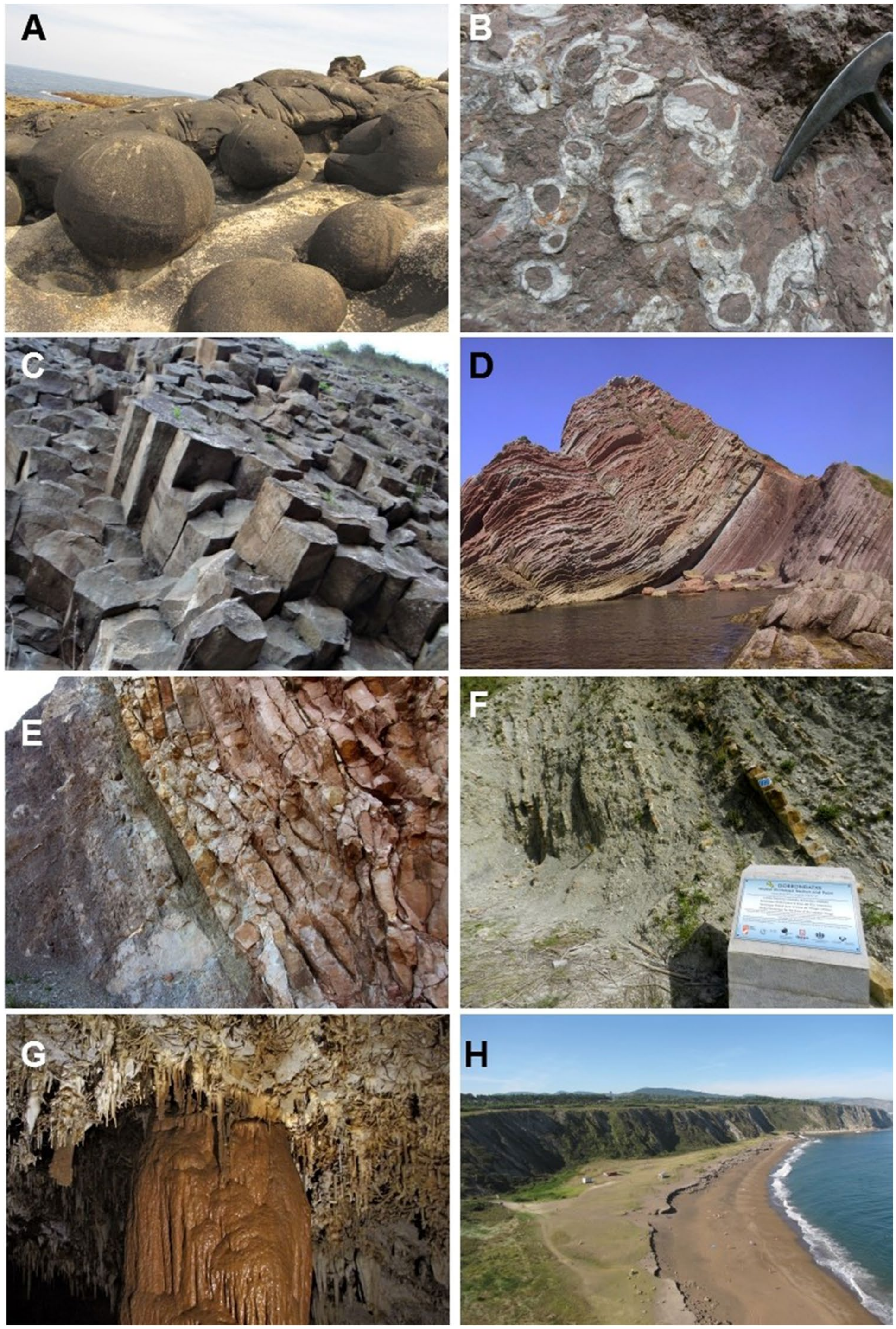

Fig. 2 An example of some Basque Geosites (I) (from: Mendia et al., 2013). **A** Geosite 136: Paramoudras of Jaizkibel; **B** geosite 15: red limestones of Kantera Gorria; **C** geosite 36: basalts at Fruiz; **D** geosite 43: K/P limit in Zumaia; **E** geosite 44: K/P limit in Sopelana; **F** geosite 49: Eocene of Gorrondatxe (GSSP); **G** geosite 64: Pozoloagua cave; and **H** geosite 96: cemented beaches of Gorrondatxe and Tunelboca

to ensure its sustainability. For these areas, LMGs only promote actively conservation and environmental restoration activities. LMGs also permit extensive recreation, livestock, forest use and certain infrastructures which are subject to development planning. All activities incompatible with the general criterion and all buildings except those of public or social interest are prohibited. In addition, the LMGs establish the importance of geosites as a tourist resource that STPs must take into account.

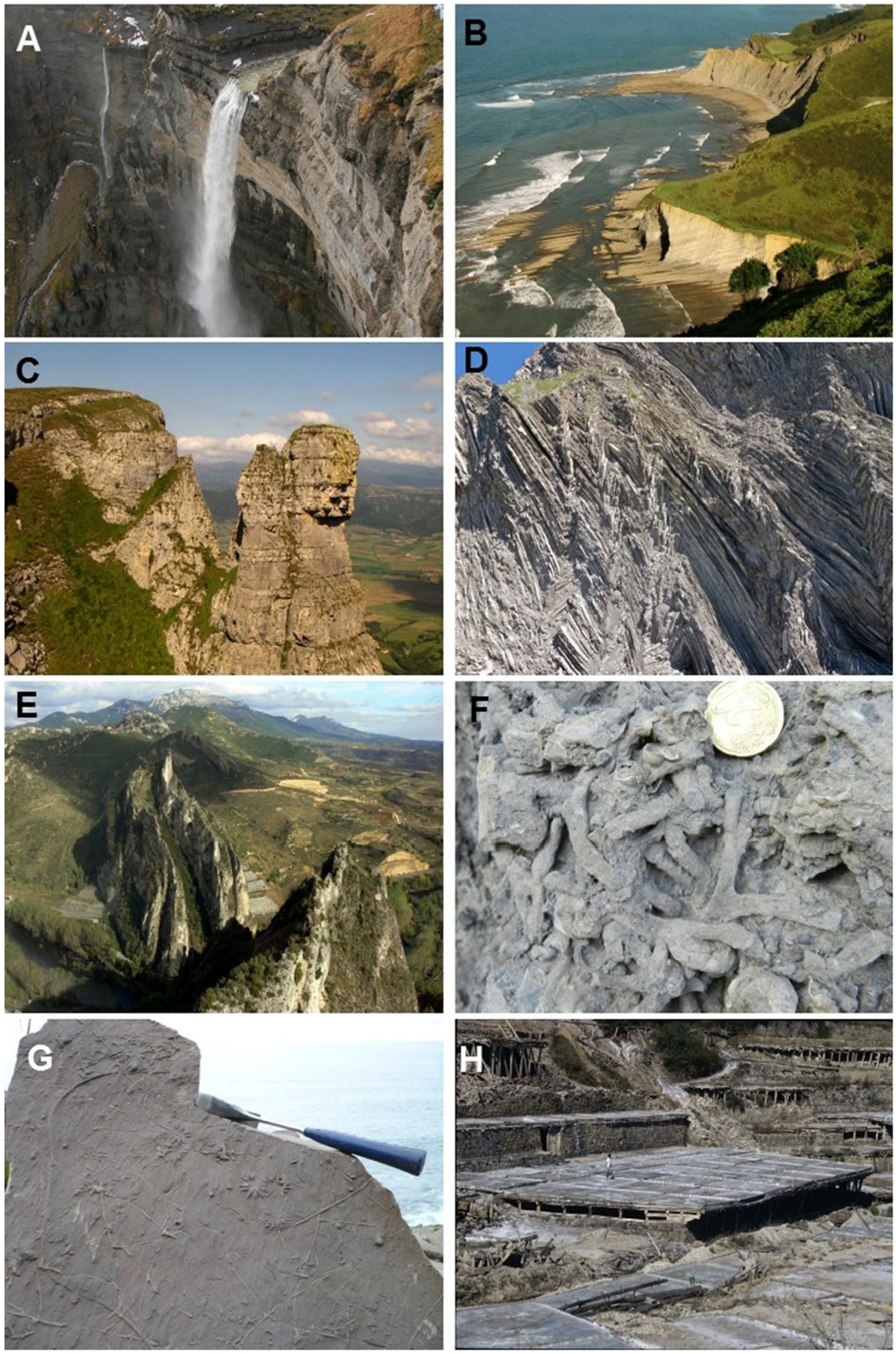

Fig. 3 An example of some Basque Geosites (II) (from: Mendia et al., 2013). **A** Geosite 69: Nerbioi cascade at Delika canyon; **B** geosite 101: geomorphological complex of the Sakoneta abrasion platform; **C** geosite 109: Pico del Fraile pinnacle; **D** geosite 118: Barrika and Txitxarropunta folds; **E** geosite 123: South Pyrenean frontal overthrust at Las Conchas de Haro; **F** geosite 134: corals and orbitolins at Mundaka; **G** geosite 135: Icnofossils of the Eocene flysch of Zumaia-Getaria; and **H** geosite 142: salt flats at Añana

Conclusions

The Basque Country is a very interesting territory from the geological point of view, and it has been the subject of numerous geological studies over the last 200 years. Some of the materials that appear in this corner of the planet are extremely valuable as they give us information about the evolution of a part of the history of the Earth and inform us about past and active geological processes, among other issues. Therefore, this geoheritage must be properly preserved and managed for sustainable use, and this requires an orderly strategy of action. This is what we have tried to implement in the Basque Country. We think this approach to geoconservation can be a role model for any territory because having a detailed strategy for geoheritage management is key to the success of the geoconservation actions that you want to carry out. Starting with the completion of a geosite inventory following geo-scientific methodologies in an easy-to-manage pilot zone (Urdaibai BR) first, and extending it to the whole territory, including the Basque Coast UNESCO Global Geopark, can be a very manageable approach to be replicated. In the Basque Country, the complementarity of UNESCO Biosphere Reserve and Global Geopark figures is a key piece within the geoconservation strategy. Both places work the path to sustainability taking into account nature management in a holistic way. We also consider that the protection of the Basque geosites by the territorial planning normative is a very innovative action that is also applicable to any territory.

Acknowledgements I would like to show my gratitude to the late Dr. Miren Mendia Aranguren from the University of the Basque Country, to whom I dedicate this paper. She was the main researcher of the Urdaibai BR and Basque Country geosite inventories, as well as the main collaborator in the writing of the BGE2020. She passed on 26 August 2019, at the young age of 56, leaving a big hole in our hearts, and in the geoconservationist community. I would also like to extend my gratitude to my colleagues from the University of the Basque Country and other entities and associations, whose rigorous body of work has made it possible to draw a clear strategy for geoconservation in the Basque Country and form the basis of this paper. I would also like to acknowledge Dr. Asier Hilario Orús for the work towards the Basque Geosites and Basque Coast GG inventories, his outstanding role as a scientific director of the Basque Coast GG and his incessant work as a geo-ambassador in promoting the geoheritage of the Basque Country around the world. I also want to extend my thanks to the two anonymous reviewers who with their comments greatly improved this paper.

Author Contribution Not applicable.

Data availability Not applicable.

Code Availability Not applicable.

Declarations

Conflict of Interest The author declares no competing interests.

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