



Geoheritage Inventory of the El Hierro UNESCO Global Geopark

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Abstract

In 2014 the Island of El Hierro (Canary Islands) was declared a Geopark of the Unesco network, thus becoming the first UNESCO geopark of the Canary Islands. The geological history of the Island of El Hierro can be understood through the visit of 61 geosites, which are representative of the growth and destruction of an oceanic Island in an intraplate environment. The geological heritage represented by these geosites has as foremost exponents those related to the formation of mega-landslides and the formation of extensive fields of pahoehoe lava-flows related to the historical or prehistoric fissure volcanism concerning the activity of its three rifts. This chapter describes the methodology used in establishing the geosite inventory carried out in 2019, as well as the description of the established geosites.

Keywords

Inventory • Geosite • Geopark • Geoheritage

1 Introduction

To proceed with the conservation and sustainable use of the geological heritage of any space, it is necessary to carry out the inventory of geosites (Carcavilla et al. 2009;

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García-Cortés et al. 2014; Brilha 2016). The Island Council of El Hierro presented the candidacy to be part of the “European Geoparks Network” (EGN) and “The Global Geoparks Network” (GGN) on October 1, 2012. In September 2014, the island of El Hierro it joins the EGN and GGN under the auspices of UNESCO, definitively declaring itself El Hierro Geopark. In November 2015, during the 38th General Conference of UNESCO, the approval of the “International Program of Earth Sciences and Geoparks (PIGG)” was ratified, thus entering El Hierro Geopark to form part of the World Geoparks Network of UNESCO, now renamed the UNESCO World Geopark.

The Geopark project Dossier contained a list and description of the Geosites and Geozones, which included a total of 7 Terrestrial Geozones, 3 Marine Geozones, 28 Terrestrial Geosites and 15 Marine Geosites.

Among the LIGs selected on that occasion was The Golfo Valley. The Golfo Valley is included in the Global Geosite VC010 “The El Golfo landslide (El Hierro)”. It is a part of the Global Geosites inventory for Spain (García-Cortés et al. 2008), a global inventory of the Earth’s geological heritage (IUGS project had the support of ProGEO, IUCN and UNESCO). It is representative of the “Volcanic morphologies and edifices from the Canary Islands” n° 14 geological framework for Spain (Barrera 2009).

The review of the inventory of geosites of El Hierro Geopark, shown in this chapter, is a consequence of the need to face a precise identification, description and interpretation of the component elements of the island’s geological heritage. These are understood as the whole of natural resources originated by geological processes and with scientific, cultural and/or educational value, such as the geological formations and structures, landforms, minerals, rocks, fossils, soils and other geological manifestations. They allow us to know, study and interpret the origin and evolution of the island of El Hierro, the processes that have shaped it, and the climates and landscapes of the past and present.

Thus, the present study starts from a double objective. The first one seeks to reflect the representativeness and the totality of the geodiversity of the island of El Hierro, which is barely formally characterized. The second is to identify the land and marine geosites of El Hierro Geopark.

To carry out this inventory of geosites of the El Hierro Geopark, there is a protocol already established worldwide that starts from the collection of information from the opinions of a panel of experts so that the points are selected according to their scientific values, educational, informative, tourist attraction, etc.

Therefore, this chapter will address the following aspects related to the recent Inventory of geosites of the El Hierro Geopark:

- The description of the methodology used in the establishment of geosites.
- The denomination of terrestrial land and marine geosites in El Hierro Geopark.
- The description of the proposal sheets for a geosite.
- The classification of the different geosites.

2 Methodology

To carry out the preliminary selection of geosites, the methodology proposed by the Spanish Geological Survey (IGME) (García-Cortés et al. 2000, 2014) has been followed.

2.1 Bibliographic and Documentary Compilation

The first task faced by the work team, made up of professors from the Departmental Unit of Geology of the Department of Animal Biology, Edaphology and Geology of La Laguna University, was the bibliographic and documentary compilation on the Geology of El Hierro. The information to be collected focused on four fundamental themes:

- Information available on the geological characteristics (with a multi-disciplinary nature) of the Island of El Hierro, and its geodynamic evolution. This information has included the MAGNA geological cartography and has served to become aware of the geosites that should be represented in the inventory and select the team of scientific collaborators who have been invited to participate in the selection of these geosites.
- Information on protected natural spaces and other elements of interest, both natural and historical and/or cultural heritage, as well as the legal regulations relating to them. Its interest lies in knowing, on the one hand,

what the level of protection of the elements to be inventoried can be and, on the other, what non-geological values can reinforce or complement the interest of the inventoried elements.

- Possible pre-existing geosite inventory initiatives in El Hierro Geopark. The work carried out rigorously in this field has been taken advantage of (such as the previous geosite inventory carried out in 2014, or the geosites collected in the reports of the geological sheets at 1:25,000 scale of La Restinga, Sabinosa, Valverde and Frontera).
- Guidebooks for scientific excursions and congresses carried out on the Island of El Hierro, such as the Geo-guides published by the Geological Society of Spain, as well as other guides on nature or protected natural areas that have sufficient scientific rigour.

2.2 Constitution of the Working Group and Election of Collaborating Experts

Given the complexity and variety of the geological record of the El Hierro UGG, both in time and space, it is easy to understand the need for expert collaborators in the different branches of Geology. Those support the inventory work team when selecting the most representative places for each of the themes involved in the geological diversity of the Island of El Hierro (Volcanology, Petrology-Geochemistry, Geomorphology, Sedimentology, Tectonics, Hydrogeology, Paleontology and Edaphology). Therefore, it is necessary to have experts who cover all these disciplines. The coordinating team selected these expert collaborators after analyzing the bibliography referring to the geology of El Hierro and invited them to participate in the inventory project.

2.3 Selection of the Geosites of the El Hierro UGG

To carry out a preliminary selection of all those places that, in the opinion of the work team and the expert collaborators, had the possibility of being incorporated into the inventory, we proceeded, in a similar way to that proposed by the Delphi methodology, described by García-Cortés et al. (2014), through several rounds of surveys carried out by all the experts.

Through these surveys, the experts were informed that they would carry out their geosites proposal taking into account the intrinsic values, those linked to their potential for use (scientific, educational or touristic) and those linked to their need for protection, following the proposal of Cendrero (1996), such as scientific knowledge, representativeness,

rarity, type or locality of reference, state of conservation, protection status and legislation, conditions for the observation, geological diversity, scenery, scientific-didactic-touristic content and use, and presence of other natural or cultural assets.

3 Inventory of Geosites in the El Hierro UGG

Table 1 shows the geosites proposed for the El Hierro UGG in this report, classified according to the geological contexts defined on the Island of El Hierro by the coordinating team (shield volcanism, rift volcanism, central volcanic complexes; prehistoric and historical volcanism; alluvial and fluvial-torrential processes and deposits; gravitational processes and deposits; coastal processes and deposits; geological elements submerged below sea level; volcanic or sedimentary aquifers; paleontological sites; tectonic structures; soils). This table also shows the main geological interests for each geosite. The location of these geosites appears in Fig. 1.

The table shows the geosites grouped into:

- (A) The 18 geosites representing the 33% with the highest score in the opinion of the experts consulted (shown in blue in Fig. 1).
- (B) The 29 geosites that obtained a score higher than 5, in the opinion of the experts consulted (shown in yellow in Fig. 1).
- (C) The two remaining geosites are those that the coordinating team, in light of the regional knowledge of the geology of the Island of El Hierro, included in the best-valued 33%. However, they would not have deserved the recognition of the experts consulted (shown in black in Fig. 1).

Nevertheless, although the experts consulted only proposed a submarine geosite (EH-012. Tagoro Submarine Volcano), the coordinating team considered it necessary to include the submarine geosites that were already catalogued as geosites in the El Hierro Geopark in 2014 (shown in blue in Fig. 1): EH-048. El Salto; EH-049. El Diablo Cave; EH-050. El

Table 1 Classification of the main geological frameworks identified in El Hierro UGG

Geological framework of El Hierro UGG	Main geological interest representative of each geological framework	Code	Geosite denomination
(1) Shield volcanism	Vulcanological (Vul)	EH-001	El Golfo Valley. (6). (Geo)
		EH-003	Las Playas Valley. (6). (Geo)
		EH-009	Remains of the Hoya del Verodal tuff ring
		EH-021	The pyroclastic cones dissected from the cliffs (La Punta de los Reyes)
		EH-022	El Julian. (6). (Geo)
		EH-024	Ventejis Volcano. (Geo)
		EH-036	Lava-flows loaded with xenoliths from La Caleta. (Pe-Ge)
		EH-037	The trachyte lava-flow of the El Golfo Volcanic Edifice. (Pe-Ge)
			Geomorphological (Geo)
(2) Rift volcanism	Vulcanological (Vul)	EH-011	La Hoya de Fireba. (Geo)
		EH-014	The Montaña del Tesoro volcano, its lava-flows and the Tamaduste lava platform. (Geo)
		EH-015	El Pozo de la Calcosas. (7). (Geo)
		EH-025	La Caldereta. (Geo)
		EH-026	El Juacllo de las Moleras. (10). (Geo-Pal)
		EH-028	The field of volcanoes of the Suthern Ridge. (4). (Geo)
		EH-031	The Cala de Tacorón. (Geo)
		EH-041	The montaña de Puerto Naos. (Geo)
		EH-043	The Pico de la Mata cave. (10). (Geo-Pal)
		EH-044	The Curascán cave. (10). (Geo-Pal)

(continued)

Table 1 (continued)

Geological framework of El Hierro UGG	Main geological interest representative of each geological framework	Code	Geosite denomination	
(3) Central volcanic complexes	Vulcanological (Vul)	EH-007	The Tanganasoga volcano. (Geo, Pe-Ge)	
		EH-019	The Malpaso salic deposits. (Pe-Ge)	
(4) Prehistoric and historical vulcanism	Vulcanological (Vul)	EH-002	El Lajial. (2). (Pe-Ge)	
		EH-004	The Don Justo cave. (2). (Geo)	
		EH-005	Orchilla volcanic group-eruptive fissures. Cliffs. (2). (Geo)	
		EH-012	The Tagoro Submarine volcano. (2, 8)	
		EH-023	The Lomo Negro volcano. (2)	
(5) Alluvial and fluvial-torrential processes and deposits	Sedimentological (Se)	EH-013	The Fuga de Gorreta. (Geo)	
	EH-045	The colluviums of the Barranco de las Arenas. (Pal)		
(6) Gravitational processes and deposits	Geomorphological (Geo)	EH-046	Los Jables	
		EH-017	The debris-avalanche deposits from the 2nd gravitational slide responsible for the El Golfo valley formation	
(7) Littoral processes and deposits	Vulcanological (Vul)	EH-015	The Pozo de la Calcosas. (2). (Geo)	
		EH-029	Pillow-lava and hyaloclastic rocks at the base of the Tiñor Edifice in Timijirate. (1, 10). (Se, Pal)	
	Geomorphological (Geo)	EH-020	The Roques de Salmor. (1). (Vol)	
		EH-030	La Maceta. (4)	
		EH-033	The Roque de la Bonanza. (1)	
		EH-038	Coastal stone arches (Puntas de Gutiérrez). (4)	
		EH-040	Coastal columnar joints in the Cachopo area. (4)	
	Sedimentological (Se)	EH-027	The Arenas Blancas paleobeach. (4). (Vol, Pal)	
		EH-032	The Verodal beach. (4). (Vol)	
		EH-039	La Caleta paleobeach. (4). (Vol, Pal)	
	(8) Geological elements submerged below sea level	Geomorphological (Geo)	EH-048	El Salto. (2, 7). (Vol)
			EH-049	El Diablo Cave. (2, 7). (Vol)
			EH-050	El Bajón. (2, 7). (Vol)
EH-051			Baja Bocarones. (1, 7). (Vol)	
EH-052			El Arco. (2, 7). (Vol)	
EH-053			La Hoya. (2, 7). (Vol)	
EH-054			Baja de la Palometa. (2, 7). (Vol)	
EH-055			El Charco Manso. (Vol). (2, 7). (Vol)	
EH-056			La Caleta. (2, 7). (Vol)	
EH-057			El Bajón del Puerto. (1, 7). (Vol)	
EH-058			El Roque de la Bonanza. (1, 7). (Vol)	
EH-059			La Baja de Anacón. (2, 7). (Vol)	
EH-060			Los Negros. (2, 7). (Vol)	
EH-061	El Barbudo. (2, 7). (Vol)			
(9) Volcanic or sedimentary aquifers	Hydrogeological (Hy)	EH-042	The Garoé. (1). (Vol)	
(10) Paleontological sites	Paleontological (Pa)	EH-008	The log molds of the Montaña Chamuscada lava flows. (4). (Vol)	

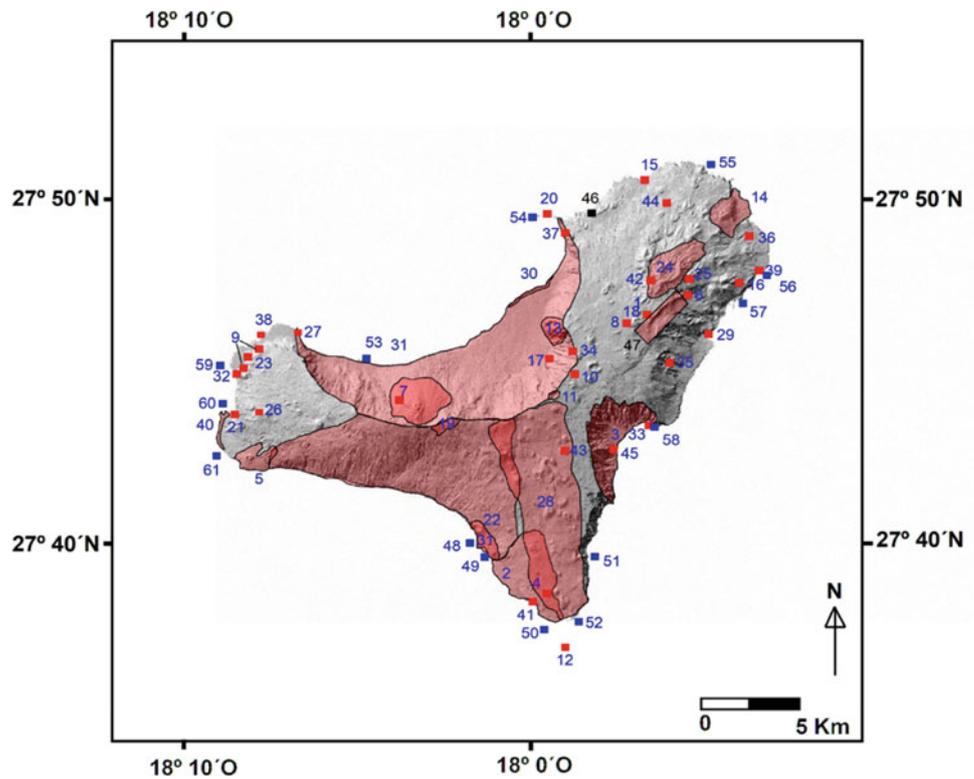
(continued)

Table 1 (continued)

Geological framework of El Hierro UGG	Main geological interest representative of each geological framework	Code	Geosite denomination
(11) Tectonic	Tectonical (Tec)	EH-006	The San Andrés fault (in the Barranco de Tiñor). (6). (Geo)
		EH-016	The San Andrés fault (in the road to Puerto de la Estaca, in Morro del Jayo). (6). (Geo)
		EH-035	Antithetical faults of the Barranco de las Playecitas. (6). (Geo)
		EH-047	The graben between San Andrés-Tiñor road and La Cumbrecita. (6). (Geo)
(12) Edaphic	Edafological (Eda)	EH-010	El Jorado
		EH-18	Jondana

It includes all geosites of all geological frameworks. Secondaries geological frameworks and secondary main geological interests are also indicated in each geosite, in parentheses

Fig. 1 Location and distribution of the selected Geosites in the El Hierro UGG (the points and areas with a red transparent grid)



Bajón; EH-051. Baja Bocarones; EH-052. El Arco; EH-053. La Hoya; EH-054. Baja de la Palometa; EH-055. Charco Manso; EH-056. La Caleta; EH-057. Bajón del Puerto; EH-058. Roque de la Bonanza; EH-059. Baja de Anacón; EH-060. Los Negros and EH-061. El Barbudo.

After establishing the geosites of the Geopark and following the Methodology proposed by the IGME (García-Cortés et al. 2000, 2014), the team coordinating this review prepared the files for the Inventory of Geosites of El

Hierro UGG. A descriptive sheet has been made for each geosite (Table 2). This descriptive sheet includes the following aspects.

- (A) The denomination of the geosite. In this case, two letters and three figures are used for the code (EH, El Hierro; 01, 2-digit code) and a name that describes the geological element and its geographical location (example: San Andrés fault in Barranco de Tiñor).

Table 2 Example of technical sheet of the inventory of geosites of El Hierro UGG

Proposal form for a geosite ^a			
Name of the geosite	EH-015. Pozo de la Calcosas		
Short description	Waterfall and lava delta formed by the arrival of lava-flows from the eruptive center of Montaña Aguarijo		
Justification of Interest	The Pozo de Las Calcosas is an excellent example of how a ravine can channel and advance the lava flows that jump a previous cliff, which fossilizes occasionally, and gain ground from the sea. It is a coastal area on cordate pahoehoe lavas that comes from two eruptive centers (Montaña Aguarijo and La Atalaya) and is located at a higher altitude. Currently, the area is affected by torrential processes, the dynamics of the slope with risks of landslides from the rocky edges of the cliff and by the action of the sea that generates interesting examples of abrasion platforms and “roques”. Geomorphological and petrological interest		
Parameters justifying the choice of the geosite (mark with a cross those that you have considered)			
<input checked="" type="checkbox"/> Representativeness			<input checked="" type="checkbox"/> Scenery
<input checked="" type="checkbox"/> Character of type or reference locality			<input checked="" type="checkbox"/> Informative content/informative use
<input checked="" type="checkbox"/> Scientific knowledge			<input checked="" type="checkbox"/> Didactic content/didactic use
<input checked="" type="checkbox"/> Conservation status			<input type="checkbox"/> Potential for recreational and outdoor activities
<input checked="" type="checkbox"/> Viewing conditions			<input checked="" type="checkbox"/> Links with other natural or cultural assets
<input checked="" type="checkbox"/> Rarity			<input checked="" type="checkbox"/> Geological diversity
Location	Province: Santa Cruz de Tenerife		Municipality (s): Valverde
	Spot(s): (s) Pozo de Las Calcosas		
	Coordinates UTM^b	X: 20,975,690 E	Y: 308,302,450 N
			Spindle: 28
			Datum: REGCAN95
	In the event of being advisable to maintain the confidentiality of the site, by concealing its coordinates, please mark it with a cross (x)		
<input type="checkbox"/>			
Access itinerary description	From Valverde, take the HI-5 towards Frontera, then take the HI-100 until the Pozo de Las Calcosas		
Situation diagram with delimitation proposal^c (insert or attach fragment of map or SIGPAC orthophoto in a separate file)			



(continued)

Table 2 (continued)

<p>Proposal form for a geosite^a</p>	
<p>Photograph (s) of the place (can be attached in separate files)</p>	 <p>Photo 1. Lava delta of the Pozo de Las Calcosas.</p>  <p>Photo 2. Detail of Photograph 1. Observe the arcs produced in the surface of the lava flow as it progresses.</p>
<p>Bibliographic references</p>	<ul style="list-style-type: none"> • Becerril, L. (2014). Volcano-structural study and long-term volcanic hazard assessment on El Hierro Island (Canary Islands) (Ph.D. thesis document). University of Zaragoza, Spain. ISBN: 978-84-617-3444-3 • Carracedo, J. (2008). Los volcanes de las Islas Canarias (IV. La Palma, La Gomera, El Hierro). Ed. Rueda, Madrid. 213 pp • Carracedo, J. C. (2011). Geología de Canarias I (Origen, evolución, edad y volcanismo). Editorial Rueda S. L. • Carracedo, J. C.; Badiola, E. R.; Guillou, H.; De La Nuez, J. y Pérez Torrado, F. J. (2001). Geology and volcanology of La Palma and El Hierro, Western Canaries. <i>Estudios Geológicos</i> 57: 175–273 • González, E.; Dóniz-Páez, J.; Becerra-Ramírez, R.; Escobar, E.; Gosálvez, R. y Becerra-Ramírez, M. C. (2015). Itinerarios didácticos y geopatrimoniales por la isla de El Hierro. Ed. GEOVOL-UCLM, Ciudad Real, e-book, 272 p • IGME. (2010). Mapa y Memoria explicativa de la Hoja de Valverde (1105-II) del Mapa Geológico Nacional a escala 1:25.000 • Pellicer, M. J. (1975). Estudio vulcanológico, petrológico y geoquímico de la isla de El Hierro (Archipiélago Canario). Tesis Doctoral, Facultad de Ciencias Geológicas, Universidad Complutense de Madrid: 179 pp • Pellicer, M. J. (1977). Estudio vulcanológico de la Isla de El Hierro, Islas Canarias. <i>Estud Geol</i> 33:181–197
<p>Author of the proposal</p>	<p>Julio de la Nuez Pestana, Francisco Javier Dóniz Páez, José Luis Fernández Turiel, Laura Becerril Carretero, Francisco Javier Pérez Torrado, Alejandro Rodríguez González, y Ramón Casillas Ruiz</p>

^a The data provided will be treated as proposals that may be modified in later phases of the inventory

^b From the geometric center of the place of geological interest

^c Optional delimitation

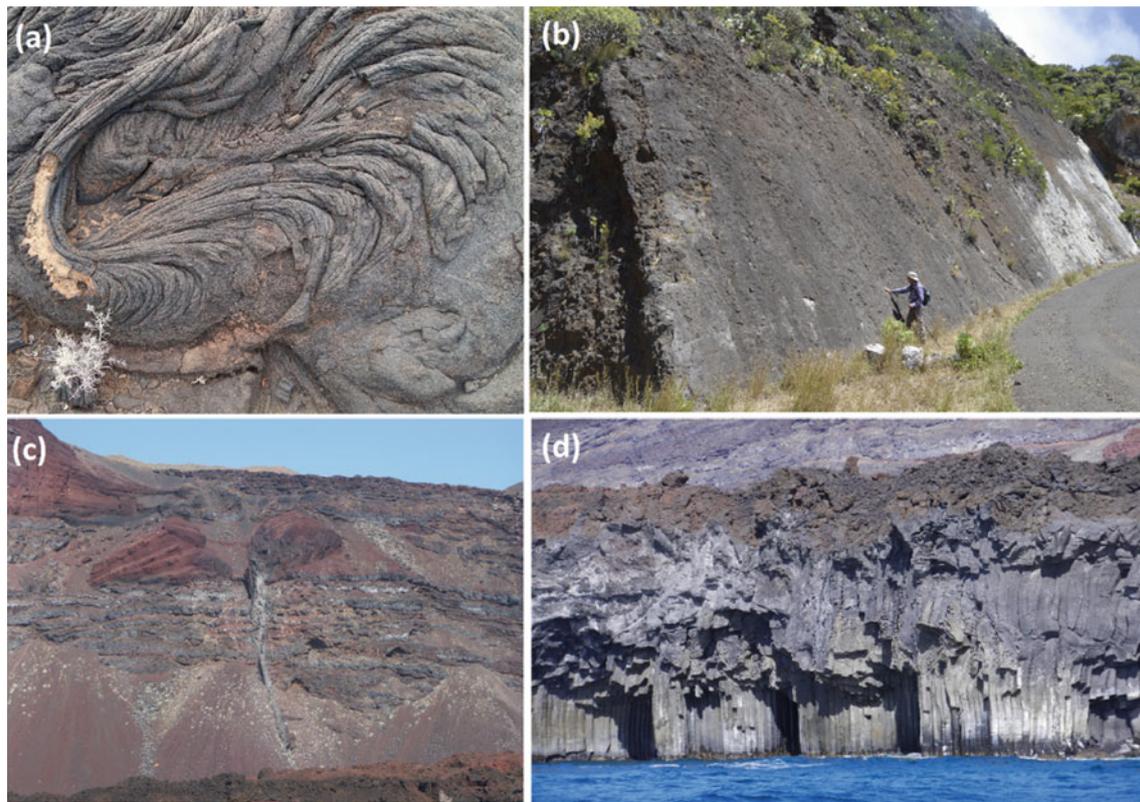


Fig. 2 Examples of some geosites from the El Hierro UGG inventory: pahoehoe lavas from the EH-002 El Lajial geosite (a); San Andrés fault slickenside from the EH-006 The San Andrés fault (in the Barranco de Tiñor) geosite (b); the pyroclastic cones dissected by the cliff from the

EH-021 The pyroclastic cones dissected from the cliffs (La Punta de los Reyes) geosite (c); and spectacular coastal caves with columnar joints from EH-040 Coastal columnar joints in the Cachopo área (d)

- (B) Short description. The description of the rocky outcrop of interest is introduced in this section, providing the essential geosite data (lithology, structure, age, etc.).
- (C) Justification of interest. In this section, it is necessary to indicate the interest rate of its content from the geological point of view: volcanological, petrological, tectonic, etc. In addition, evaluative comments are also introduced about the importance of the geosite concerning the interpretation of the geological history of the El Hierro, the exclusivity of the geosite and its relationship with other aspects of the heritage (historical, archaeological, ethnographic, etc.), as well as its valuation from the informative, didactic or recreational point of view.
- (D) Justifying parameters of the choice of the place. This section refers to the evaluation parameters that we indicate in Sect. 2.3: the intrinsic values, the values linked to their potential for use (scientific, educational or touristic) and the values linked to their need for protection. Each geosite was assigned specific valuation parameters.
- (E) Location. The province, the municipality and the toponymic name of the place where the geosite is located are indicated. The UTM coordinates of the center of the area encompassed by the geosite are also determined.
- (F) Description of the access route. This section describes the path or route to be followed to visit the geosite. The names of the arrival roads or the approaching paths are identified, etc.
- (G) Situation diagram with delimitation proposal. A map or an aerial or satellite photo with the delimitation of the geosite is also added for a better location.
- (H) Photograph (s) of the place. In this section, the photographs were deemed appropriate for better identification and description of the geosite.
- (I) Bibliographic references. This section lists the books, geological maps, scientific articles, etc., which describe the characteristics of the geosite.
- (J) Author of the proposal. This last chapter indicates the members of the panel of experts who have proposed this outcrop as a geosite in the survey launch phase, described in Sect. 2.3 of this work (Table 2).

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