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GEOMORPHOSITES AND GEOTOURISM IN VOLCANIC LANDSCAPE: THE EXAMPLE OF LA CORONA DEL LAJIAL CINDER CONE (EL HIERRO, CANARY ISLANDS, SPAIN)

Javier DÓNIZ-PÁEZ*
Department of Geography, University of La Laguna, Tenerife, Involcan, Canary Institute of Volcanology, Tenerife, Puerto e La Cruz, Spain, e-mail: jdoniz@ull.es

Rafael BECERRA-RAMÍREZ
Geovol, Department of Geography University of Castilla La Mancha, Ciudad Real, Spain, e-mail: rafael.becerra@uclm.es

Elena GONZÁLEZ-CÁRDENAS
Geovol, Department of Geography University of Castilla La Mancha, Ciudad Real, Spain, e-mail: elena.gonzalez@uclm.es

Cayetano GUILLÉN-MARTÍN
Involcan, Canary Institute of Volcanology Tenerife, Puerto e La Cruz, Spain, e-mail: cayetanoguillenmartin@hotmail.com

Estela ESCOBAR-LAHOZ
Geovol, Department of Geography University of Castilla La Mancha, Ciudad Real, Spain, e-mail: estela.escobar@uclm.es

Abstract: Geomorphosites and geotourism in volcanic landscape: the example of La Corona del Lajial cinder cone (El Hierro, Canary Islands, Spain). Volcanic landscapes are very often visited by tourists. This paper underlines the relevance of geomorphological heritage as a tourist resource through an assessment of the different geosites (scientific or intrinsic values, cultural or added values and use and managements values) present in La Corona del Lajial Volcano, located in the Canarian island of El Hierro (Spain). El Hierro receives a type of sustainable tourism related to its ecotourist offer based on products like diving or hiking. However, the volcanoes on the island are not appreciated enough as a tourist attraction. The objective of this paper is to highlight the tourist potential of volcanic geomorphology as a tourist resource and alternative activity to diving, by means of the creation of new ecotouristic products such as volcanic hiking.

Key words: Geomorphosites, sustainable tourism, volcanic geomorphology, mafic volcanism, El Hierro, Canary Islands

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INTRODUCTION

Natural heritage implies a wide view of the biotic, abiotic and antropic aspects of the territory and constitutes the most important identity feature attesting to the preservation of their territory by any people. However, currently the biological criterion dominates when speaking about natural diversity, whereas geodiversity occupies a secondary position and hidrodiversity is generally overlooked (González-

* Corresponding author

Trueba, 2006). While natural diversity is closely linked to biological patrimony, geomorphology has only been taken into account as an aesthetic, landscape value. All in all, biodiversity as much as geodiversity and hidrodiversity are part of natural diversity (Serrano and Ruiz-Flaño, 2007), which turns into some of the main territorial resources on which to base many of the present practices of the so-called sustainable tourism.

Hiking tourism, which combines sports activities and the appreciation of Nature, is today one of the principal economic activities in the natural protected areas of the Canary Islands (Dóniz-Páez, 2010 and Guillén-Martín et al., 2010), and among the markets that will experience a great increase in a near future (Coratza et al., 2008).

People visit volcanoes for a variety of reasons, the major one is probably the fascination of being close to the power of nature (Sigurdsson and Lopes-Gautier, 2000), followed by religious beliefs (Donovan, 2010). Additionally, volcanoes produce multiple benefits for society (agriculture, geothermal energy, rocks, minerals, tourism, etc.) (Dóniz-Páez et al., 2010 d); however, the major economic resource that stems from volcanoes is tourism (Sigurdsson and Lopes-Gautier, 2000). For example, in the case of Spain, the most visited natural protected area is the National Park of Las Cañadas del Teide, Tenerife Island (Dóniz-Páez, 2010), formed by a number of volcanoes of enormous complexity and a beauty landscape (Martínez de Pisón et al., 2009).

The volcanic landforms, therefore, stand out as a factor to consider, an exceptional geomorphological heritage for science and an unquestionable social value. Even so, there hardly exists any interest in including territorial shapes, in general, and the eruptive ones, in particular, as one of the essential touristic attractions when designing itineraries, routes or circuits, although they are inescapably present in all of them.

The objetive of this paper is two-fold: the first one, it tries to list the different geosites of La Corona del Lajial Volcano (figure 1) to eventually propose that these geosites, given their touristic potential, are finally made part of the general offer found in El Hierro Island. The first objective relies on the fact that this is one of the enclaves with the highest geodiversity on the island (Dóniz-Páez et al., 2010a and b), with an outstanding geomorphological landscape, and highly appreciated, well-preserved natural values, which brings about the need to increase the level of protection. The second objective rests on the physical proximity of this place to La Restinga, the main seaside touristic nucleus on the island. The sustainable tourist offer here is almost exclusively dedicated to diving in the marine reserve of El Mar de Las Calmas, which, given the temporal restriction to divers, makes it possible to diversify the market and combine the activities connected to sea sports and sun and beach with scientific tourism, excursions or volcano trekking.

STUDY AREA

La Corona del Lajial Volcano (CLV) is a quaternary mafic cinder cone on El Hierro Island. This monogentic volcano is in the south rift of the island (UTM: 204117-3064424) (figure 1) and formed by different volcanic ediffices along the 1.2 km eruptive fissure. The products present in the volcano are pyroclastic materials (lapilli, bombs, scorias, spatter) and important lava flows (Los Lajiales). The age of CLV is recent <20Ka (Carracedo, 2008) and it presents a fresh and complex volcanic geomorphology.

Two climatic conditions are recognized in La CLV. The upper sectors possess a temperate-warm climate with average temperatures of 19°C, total precipitations between 200-600 mm/year and with a number of dry months between 7 and 8. In the coast, the climate is warm, with average temperatures of 22°C, with rains <350 mm/year and the dry months are >8 (Marzol, 2000). These climatic characteristics determine that erosion processes, vegetal colonization and human occupation in the volcanic lanforms are not very important.

These conditions also account for the presence of the coast scrub (*Periploca laevigata*, *Euphorbia obtusifolia* and *Rumex lunaria*). The climate and the type of volcanic products bring about a different occupation density. For this reason, under temperate-warm climate, the vegetation is more important than under warm climatic conditions. Likewise, the colonization of the vegetation is more significant in the pyroclasts than in the lava flows.

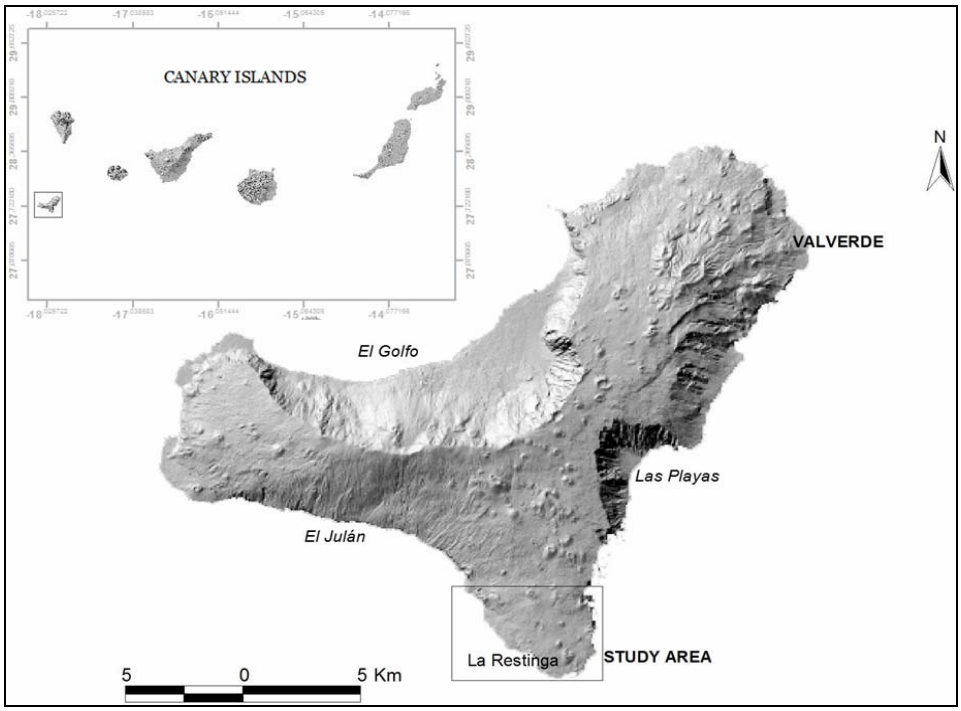

Figure 1. Location of study area (La Corona del Lajial volcano) in the Canarian Island of El Hierro

The recent volcanism, the scarce rains and the scrub vegetation, meaning unclear account for human occupation of the territory. In this part of El Hierro, there is only a village, La Restinga. This village is located on the coast and the main traditional economic activities are fishing, the growing of cereals and shepherding. Now, sustainable tourism is being boosted as an economic resource, with diving and hiking.

METHODOLOGY

The methodology implemented in this paper is based on the traditional procedures in volcanic geomorphology and the actual consideration of geomorphological heritage (figure 2). The analysis has been built on a bibliographical revision, topographical and geological maps, aerial photographs and field work. All this information has helped in the creation of a geomorphological map. Once each of the geomorphological forms and processes present in the volcano was identified, listed and mapped, the relative relevance of each of them was measured against factors as genesis, number, size, singularity, etc., and then, the most representative and singular elements, the geomorphosites, were selected using the geomorphological map.

The geosites went through a semi-quantitative assessment thanks to the methodology used previously by other authors in natural protected areas (Serrano and González-Trueba, 2005; González-Trueba, 2006; Serrano et al., 2006; González-Trueba

and Serrano, 2008), now with the introduction of that one specified for volcanic territories (Dóniz-Páez 2009; Dóniz-Páez et al., 2007, Dóniz-Páez et al., 2010a). This methodology is based on the quantification of the scientific or intrinsic values, cultural, or added values, and use and management values of the different geosites (Serrano and González-Trueba, 2005). According to the values obtained for any of the geomorphosites, their use will be different. In this sense, several uses can be proposed: natural, cultural, didactic, touristic etc.

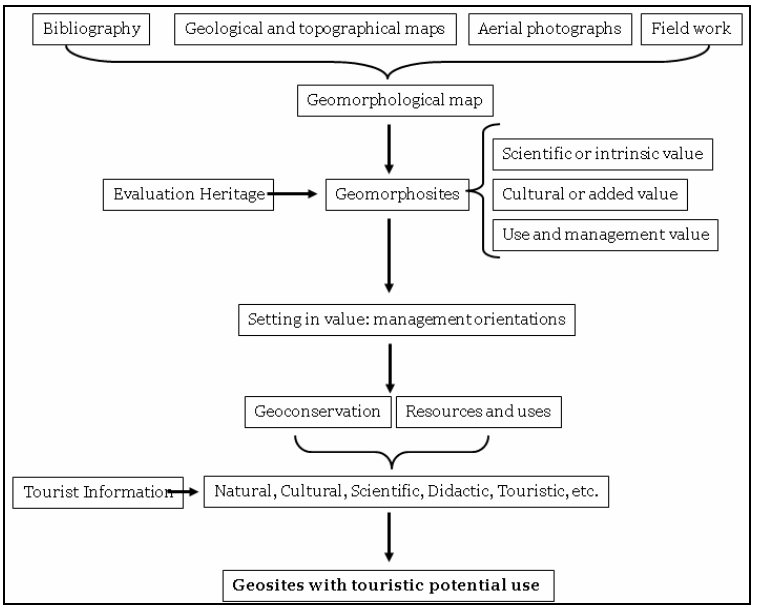

Figure 2. Methodology for geomorphosites determination and his touristic potential

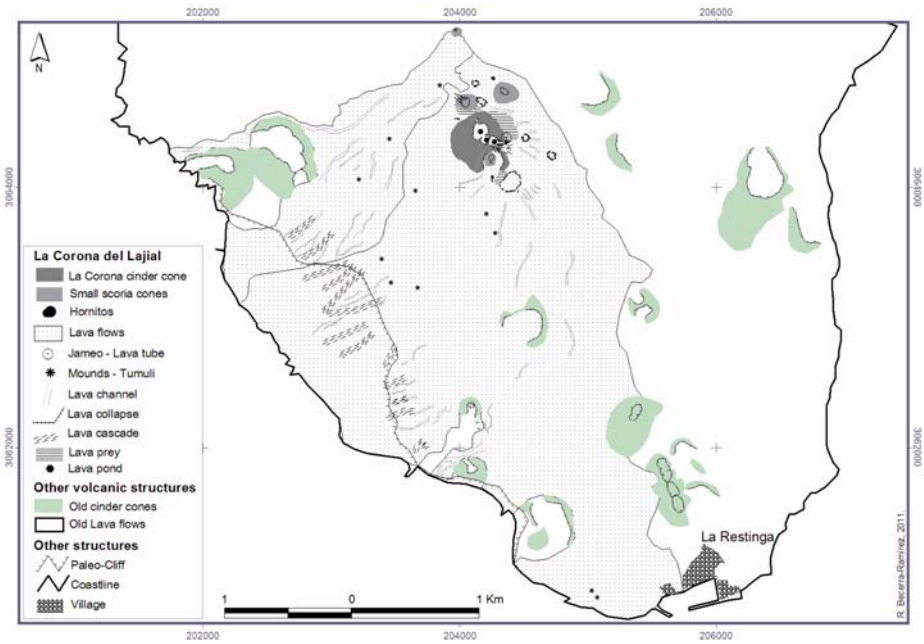

Figure 3. Geomorphological sketch of the La Corona del Lajial monogenetic volcano

RESULTS AND DISCUSSIONS

Volcanic geomorphology: forms, deposits and processes

Two important groups of forms can be identified in the CLV, namely, those associated with an explosive activity, and those connected with an effusive one (figure 3). The volcanic edifices correspond to the former, and the small scoria cones, *hornitos* and the accumulations of pyroclasts; the lava flows and their different morphological forms (small lava lake or pond of lava and lava cascade lava collapses, lava tubes, *jameos*, channels of lava etc.), to the latter.

Volcanic edifices. In the CLV three types of eruptive edifices can be distinguished: cinder cones, small scoria cones, and *hornitos* (figure 4). Although the former is the most outstanding in a volcanic landscape for its dimension, the others are more numerous. In each of the volcanic cones the characteristic elements of basaltic monogenic volcanoes are likely to be recognised (Dóniz-Páez et al., 2008; Dóniz-Páez, 2009), as also are the processes and sedimentary erosive forms typical of the initial phases of the dismantling of eruptive territories (Dóniz-Páez, 2006).

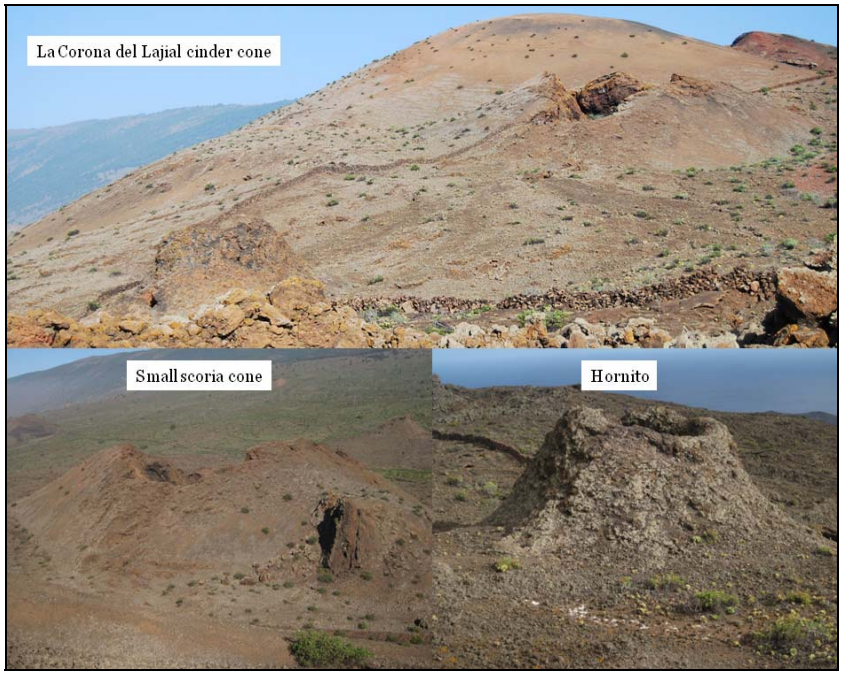

Figure 4. Different edifices of La Corona del Lajial volcano: 1- cinder cone, 2- small scoria cone and 3- hornito

Cinder cones of La Corona del Lajial volcano constitute an eruptive edifice of multiple morphology according to the classifications of irregular bases, and formed by lapilli, bombs, scoria and spatter deposits and interstratified lavas (Dóniz-Páez 2009). The most significant feature of the volcano is the presence of several craters with different eruptive morphologies, behaviours and dynamics, from simple explosion craters of minimal size (< 5 metres deep) and specialized only in gas emission and lapilli in the north area of the edifice, to the ample craters (> 50 metres deep) in the central and south sectors of the volcano with their own ponds of lava, and thus indicating an important effusive activity.

The *small scoria cones* are foci of usually explosive activity that produce scoria edifices, usually of reduced size, of semi-circular basis and having explosion craters.

They are constituted by the accumulation of lapilli, and especially that of spatter and scorias. In the CLV four types of buildings of these edifices can be found, with a size superior to the usual, over 30 metres high and spitting abundant lavas that can flow for several kilometers.

The hornitos are the smallest eruptive edifices in the CLV and they are not higher than 5 metres. They present irregular bases as a consequence of the association of various *hornitos* constituted by deposits of spatter, and eruptive centers that connect with channels of lava through which gases, pyroclasts and small pahoehoe lava flows are emitted.

The eruptive edifices are being remodelled by erosion processes. The most significant are the colluvial and torrent processes that originated talusees and gully forms. There is no doubt that the most important erosion is man-made, due to the opening of paths and tracks, grazing and the building of stone walls, which have partially destroyed the original morphology of the cones.

The volcanic lava fields: pahoehoe (lajiales) and aa (malpaíses). The most important trait of this volcanic zone is the long lava field. They are the predominant forms in the landscape of the CLV having a well-preserved state, and an extraordinary variety of superficial morphologies, forms and structures.

In the lava field of the CLV it is possible to differentiate several types of superficial morphologies. The *pahoehoe* or *lajiales* lavas, of straight surface or slightly corrugated with folds, rich in detail morphologies, of scarce thickness, long flow and coming from the ponds of lava near the centres of emission and from *hornitos*. The *aa* or *malpaíses* lavas have as main feature a broken surface, rough, corrugated and made of heterometric and mobile fragments. And last, the *blocks lava flows,* of irregular morphology.

In the lava field of the CLV minor and major forms can be seen. As regards the former, it is in place to remark the existence of ponds of lava, cascade lavas, leveés, channels of lava, the lava tubes, mound or tumuli and *hornitos*, whereas the latter include erratic blocks mainly.

The ponds of lava and the lava collapses (figure 5) are one of the most remarkable structures in the lava field of the CLV. They are semi-circular structures made by the superposition of pahoehoe lavas of scarce thickness expelled in a radial emission from a culminating depression through several lava tubes, micro-lava tubes and channels, similar to the ones firstly described for Timanfaya in 2008 (Romero-Ruiz et al., 2008). The bottom of these ponds can be formed by a chaotic block surface, or by the injection of pahoehoe lava flows, which do not overflow the rim. These depressions are a consequence of the rapid emptying out of the pond through the lava tube system, micro-lava tubes and channels already mentioned. The cascade lavas (figure 5) are associated with the sectors where the lava flows have circumvented relevant surface irregularities, in some cases over 50 metres, and that is why they appear covering the paleocliff. The lava preys (figure 5) correspond to these sectors where a previous obstacle engenders a depression that avoids the advance of the lava tongues, and these, when stopped, fill up the vacant depressed space. The channels of lava (figure 5) and lava tubes are related to each other and their genesis is due to a differential cooling process in the ravine, dissimilar from that of the banks. The difference lies in a tube that supports the ceiling, and when this collapses, it allows seeing its interior through the *jameos*, while the other two do not. The tumuli result from the processes of degasification of the pahoehoe lava streams during their flow, where pressure causes an inflation of the surface of lavas.

The lava fields are also affected by these processes of meteorization and edafogenesis, but as it happens with the volcanic edifices, man-made actions engender the most significant effects: growing fields, stone walls, paths, tracks and roads, extraction of tiles for ornamentation etc.

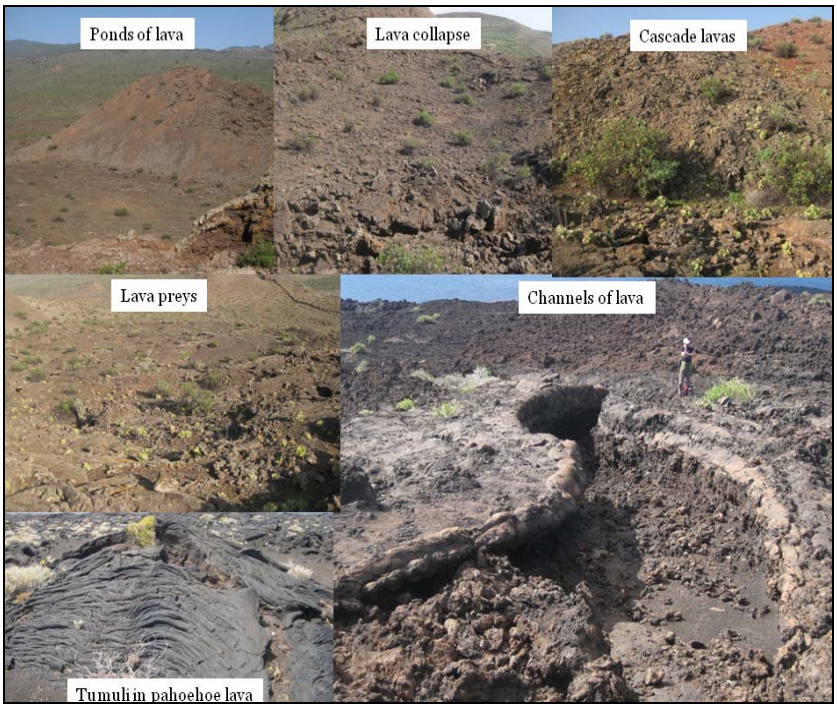

Figure 5. Volcanic landforms in the lava field: 1- ponds of lava, 2- lava collapse, 3- cascade lavas, 4- lava preys and 5- channels of lava

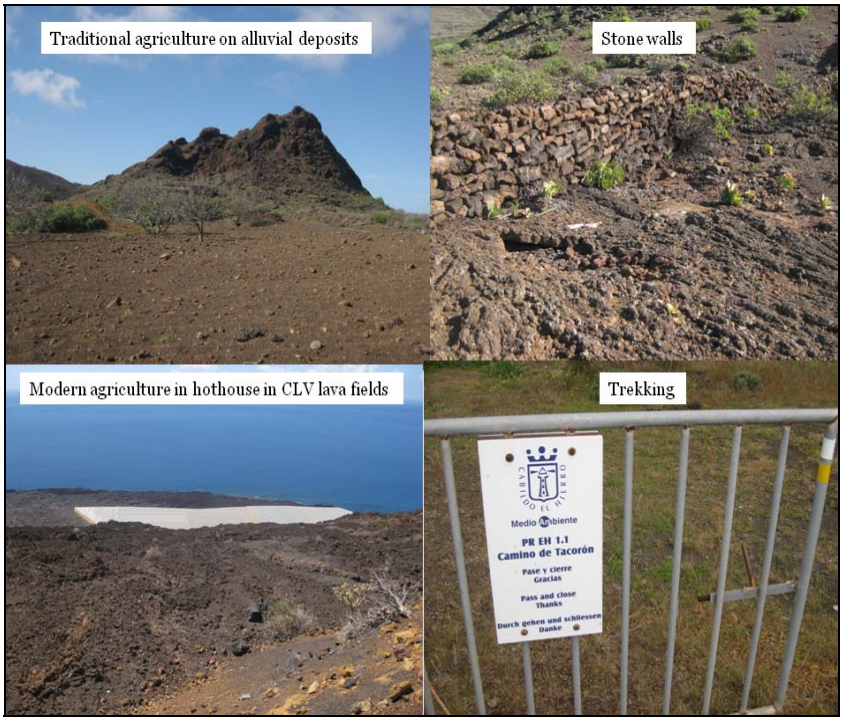

Figure 6. The human uses in the La Corona del Lajial volcano: 1- traditional agriculture on alluvial deposits, 2- stone walls, 3- modern agriculture in CVL lava fields and 4- trekking

The uses of volcanic lanscape

The Canarian volcanoes are important socioeconomic resources for the inhabitants of the islands and pyroclastic materials and lava flows have been consistently used. La Corona del Lajial volcano descends from an altitude of 500 meters to sea level. This clarifies that the volcanic products are under different bioclimatic conditions, which in turn brings about different uses of the volcano. The main resources obtained from the CLV are conditioned by this fact. In this sense, in the most elevated sectors, more humid and with a dense vegetation cover, the uses are related to the growing of cereals and fruits (traditional agriculture) and the extensive goat and sheep grazing (figure 6). The human imprint in these areas is present through a landscape of small fields enclosed by stone walls (figure 6), where windmill stones for grinding wheat can be easily found, altogether with *aljibes* (traditional systems to collect rain water), and stables. In the zones closer to the seashore, drier and with a thinner vegetation cover, the uses are connected with modern agriculture on hothouse (figure 6) fishing and diving tourism in the marine reserve of El Mar de Las Calmas, trekking (PR EH 11 Tacorón-Pinar) (figure 6) and, to a lesser extent, sun and beach tourism in La Restinga and in Tacorón beaches. Therefore, the uses mentioned above endow the volcanic landscape of the CLV with an interesting cultural value.

Geomorphosites in volcanic landscape

The relief alone can constitute a component of the cultural or scientific heritage of a territory (Ilies and Josan, 2009). The original geomorphology of the CLV together with the geographical peculiarities of this area of El Hierro (recent volcanism, semiarid climate on the coast and humid on the heights, soaring topography, low population rates, notable differences of vegetal colonisation, sea erosion, etc.) result in a high level of geodiversity.

Table 1. Values of the geosites of the La Corona del Lajial volcano

Identification	*Number*	Geosites type	Scientific	Cultural	Use
1	1	Cinder cones	4,2	2,6	10
2	4	Small scoria cones	4,3	3	6
3	2	**Hornitos**	3,5	2,9	5
4	4	Lava collapses	3	2,2	11
5	4	Cascades of lava	3,2	2,7	7
6	2	Pound of lava	3,1	2,8	3
7	3	Lava prey	2,4	2,1	11
8	1	*Jameos*-lava tubes	4	2,3	4
9	3	Pahoehoe lavas	7	4	5
-	Total: 24	Average values	3,9	2,7	6,9

As a whole, nine geosites have been identified, which means 24 places (table 1 and figure 7), with a triple valorisation for each of them. Intrinsic and added values are assessed according to Serrano and González (2005), on a 0-10 scale, and its grading may give an idea of the dominant value (natural or cultural) in the geosite and how it has been used and how it should be managed. The assessment of the cluster and each geosite of the CLV shows higher rates for the natural values than for the cultural ones, which is in agreement with this natural protected area, one which, although having antropic imprints, still preserves the original morphology of it relief. The CLV concentrates the highest geodiversity in volcanic edifices, as opposed to the lava flows. This underlines that the volcanic cones possess a higher geodiversity than the lava flows (figure 7). This fact allows to see that the uses need to be different, and in agreement with the high or low geodiversity level in a given sector, being primordial the tourist use of lavas and the didactic one in the cinder or scorias cones.

The data obtained reveal that it is still all the most necessary the consideration of the CLV as a natural protected area. However, given its singularity and geomorphological representativity, it might be needed as well to endow the site with the uses proper of higher categories of protection (scientific, didactic and ecotouristic) with Natural Monument and Special Reserve labels.

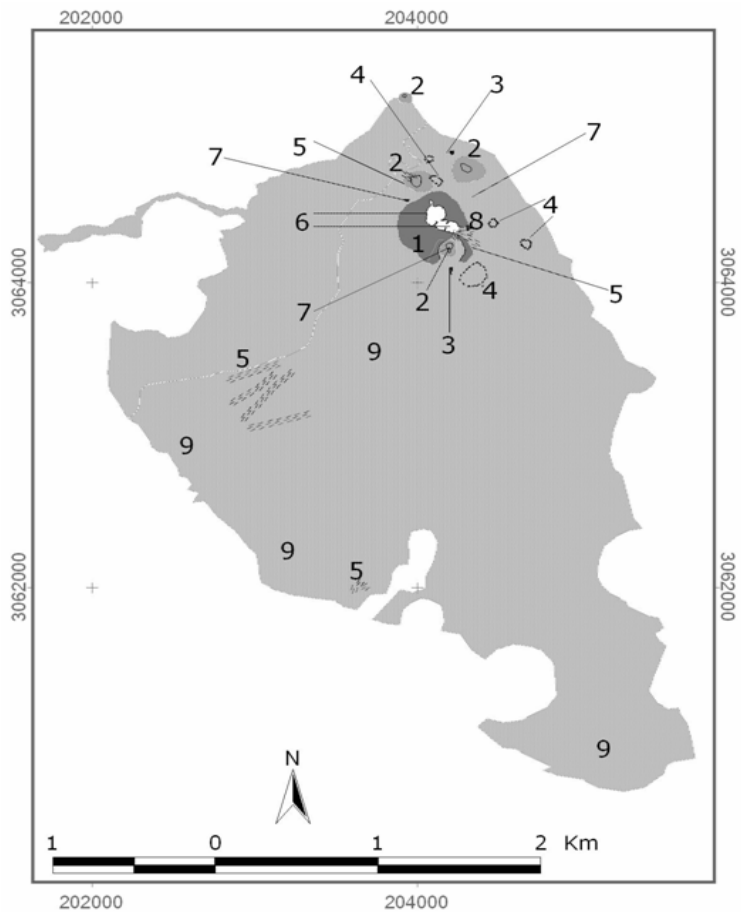

Figure 7. Sketch of the map of geomorphosites of La Corona del Lajial Volcano (for numbers see table 1)

Geotourism, ecotourism and sustainable tourism

The Canary Islands are a first-class world tourist destination. As different from other islands of the archipelago, which construct their offer on sunshine and sand model, El Hierro offers a sustainable alternative product resting on any of its natural attractions such as diving or hiking. The profile of the tourist visitor of El Hierro is one that shows a great sensitivity to Nature, and respect for the local population, and hence she/he is likely to be easily integrated in the host culture of the island.

Over the 58% of the territory of El Hierro is protected according to the Canarian environmental legislation, which turns it into the Canary Island with the highest portion of protected territory in relation to its overall surface (AAVV, 1995). Additionally, the island has a marine reserve, it has been declared as Biospheric Reserved Space, and will be the first of the Canary Islands in basing its ordinary supply on renewable energy. All this intends to ensure the exceptional natural conditions of the island to avoid the human

action and pressure on the territory, and will further condition the future touristic offer based on ecotourism and sustainable tourism. Ecotourism consists in "*low impact nature tourism which contributes to the maintenance of species and habitats either directly through a contribution to conservation and/or indirectly by providing revenue to the local community sufficient for local people to value, and therefore protect, their wildlife heritage area as a source of income*" (Fennel, 2008).

In 2010 El Hierro received more than 34,300 visitors (Frontur-Canarias), a relatively low entry rate in relation to the visitors of other islands such as Tenerife (2,950,995) or Gran Canaria (2,462,980), but significant enough to question which might be the total tourist yield of the island, and especially in the light of data showing that the local population of El Hierro is 10,960 inhabitants (ISTAC). When observing figure 8, it will be noticed that the majority of visitors in El Hierro are hikiers (71.58%), and to a lesser extent tourists (28.42%). This can be explained by resorting to the vast insular offer centred on ecotourist activities: diving, excursions, trekking, observation of natural landscapes, gastronomy, local festivities, etc.

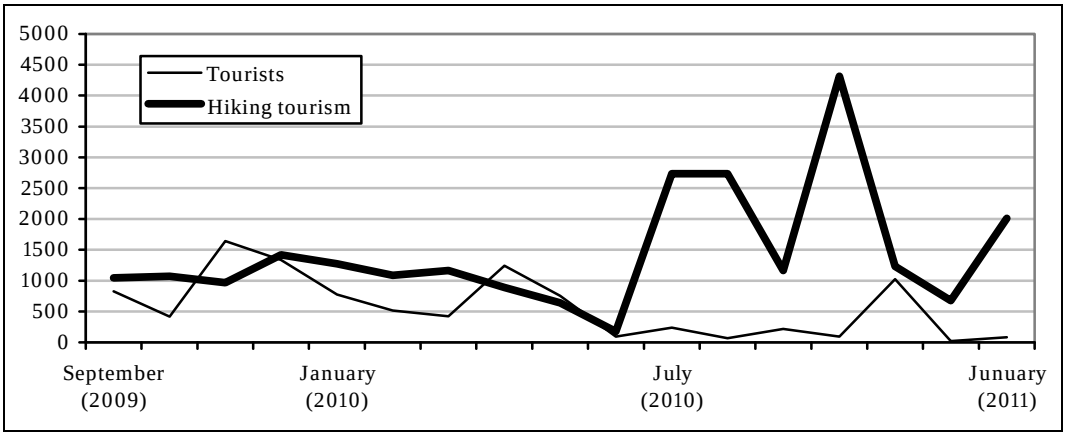

Figure 8. Evolution of tourists and hiking tourism that arrive to the El Hierro (2009-2011)
(Data source: Frontur-Canarias, Istac. Self elaboration)

Volcanoes punctuate the geography of El Hierro and constitute a touristic resource of their own within the general offer marketed by the Regional Government. Nevertheless, El Hierro volcanic geomorphology and the different geosites are not directly present in the touristic offer of the island. This fact evinces the lack of a firm bid for the volcanic relief to play a key role as a tourist resource in El Hierro and its various touristic itineraries (Dóniz-Páez et al., 2010 c and e). Such a fact can be easily connected with that revealing that the majority of the visitors who come to the Canary Islands are interested in enjoying the sun and local beach offer, which, in turn added to the popularity of the islands as vacation resort, brings about a number of drawbacks for the volcanoes of the islands (Lopes, 2005), especially when devising tourist products branded as volcanoes (Dóniz-Páez et al., 2010d).

CONCLUSIONS

The geomorphological potential of volcanoes in the Canary Islands is mostly underused as tourist resource. There are hardly any exceptions in which the volcanic relief features predominantly among other tourist products offered. Yet these cases also show a clear prevalence of aesthetic or "*landscape*" values over the geosite.

The geomorphology of the CLV is an exceptional instance of the basaltic monogenic volcanism typical of the Canary Islands, and its geodiversity is unique in the

whole archipelago. La Corona del Lajial Volcano presents high rates of geodiversity (table 1) in relation to the complexity of the eruption that originated it, to the geomorphological evolution, the recent age, the different climatic conditions that it hosts, to its being a protected natural space, the scarce population and the peculiar use that people have made of the CLV.

Figure 9. Aerial view of La Restinga villaje, lava field from CLV and Mar de Las Calmas Sea, Photo courtesy of Carmen Romero

La Corona del Lajial Volcano is close to the main touristic centre on the island (La Restinga), whose principal offer is diving in the Mar de Las Calmas (figure 9) and international *fotosub* safari. This, together with its great natural diversity (geodiversity and biodiversity), the existence of paths that traverse its lava fields and cinder cones and the impossibility of divers to be too much time immersed, which means that they have some free time, are reasons powerful enough to shape a

potential offer and demand of this protected natural space as tourist resource. This gains special relevance in the light of the recent submarine eruption (in progress from 10 October 2011) near La Restinga village (see www.ign.es), which has impeded the main tourist attraction in El Hierro, diving.

Therefore, new tourist products can be promoted and new activities encouraged, which can serve as an alternative to diving. Such is the case of paths among lavas and volcanoes. The goal of these activities is to use the volcanic relief as an ecotouristic activity that can make visitors aware of the touristic potential of volcanoes in El Hierro.

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