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Geotourism on an active volcanic island (La Palma, Canary Islands, Spain)

Abstract
The aim of this study is to assess the importance of geotourism before, during and after the eruption of the Tajogaite Volcano (September to December 2021) on La Palma, Spain. The methodology applied consisted of identifying the geotourism products on the island before the eruption, the importance of the volcano for geotourism – by means of a survey – and the geotourism products developed after the eruption. The findings show that, before the eruption, La Palma's tourism products (hiking, archaeology, stargazing and volcano tourism) were closely related to its volcanic heritage. During the eruption, Tajogaite became a tourist attraction for the island, drawing thousands of visitors and scientists. Lastly, now that the eruption has ended, geotourism is playing a key role in the various island recovery plans through the evaluation of sites of geotourism interest and the design of geotrails in natural and urban areas.

Keywords
Volcanic heritage • geotourism • Tajogaite Volcano • La Palma, Spain

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Introduction

Tourism is a complex, dynamic and sensitive economic activity that may be affected by changes that range from the global to the local. The best recent example of drastic change in tourism at the global level was the COVID-19 pandemic, which brought global tourism to a standstill (UNWTO 2020). However, the effects on tourism can also be observed on a local scale, as with the eruption of the Tajogaite Volcano in La Palma in 2021. However, tourism has proven to be a resilient activity with the capacity to recover on a global scale, as seen on other occasions, such as after the 2008 global financial crisis. Moreover, major disruptions in tourism often become opportunities, as in the case of the emergence of new tourism products that diversify leisure offerings at the site of the disruption. This is achieved through the creation of innovative experiences that set destinations apart as unique on the basis of their local heritage. The sustainable use of tourist attractions and resources associated with natural and cultural heritage underpin the creation of these tourist products. In the case of the island of La Palma, the devastating negative effects of the eruption have contributed to further strengthen sustainable tourism activities related to its volcanic heritage.

The main economic activities on La Palma are export agriculture and tourism (Istac 2023). However, unlike other Canary Islands where the main focus is on 'sun-and-beach tourism', La Palma has historically opted less for mass tourism than for more sustainable tourism based on activities related to its natural and cultural heritage. The main tourist attractions on La Palma, therefore, revolve around its volcanic heritage, and comprise hiking, archaeology and stargazing (Tourism Chair 2016, Fernández-Hernández et al. 2022).

Volcanoes and their associated heritage are the main tourism assets of La Palma. Therefore, geotourism activities have played an essential role in tourism on the island over time, as confirmed by the activities that emanated from the historic eruptions of San Juan in 1949, Teneguía in 1971 (Actualidad Española 1971) and, more recently, Tajogaite in 2021 (Dóniz-Páez et al. 2024). This latest eruption has brought the importance of volcanic tourism for the island, as compared with other types of activities, to the forefront. Thus, with the aim of assessing the role played by volcanoes as tourist attractions and resources on La Palma, this article will assess the importance of geotourism before, during and after the eruption in 2021 through the products and activities that already existed, those that have been generated and those that are in the process of being created.

Study area

La Palma, lying at the north-western edge of the Canary Islands (Fig. 1), is an oceanic, subtropical, active volcanic island with a surface area of 707.84 km^2 (708.32 km^2 after the eruption of the Tajogaite Volcano in 2021) and a maximum elevation of more than 2,420 metres above sea level (Istac 2023). The formation of La Palma began four million years ago (4 Ma) with undersea eruptions. Once the base of the island had formed, subaerial uplift began between 3 and 2 Ma. Subsequently, between 1.77 and 1.20 Ma, the Garafía volcanic edifice formed, followed by a landslide. Between 0.8 and 0.6 Ma, the Taburiente edifice formed, during which several phases may be identified. Then, between 0.77 and 0.56 Ma, to the south of Taburiente, the Cumbre Nueva edifice was formed, which eventually collapsed. This was followed by the formation of the new Bejenado volcanic

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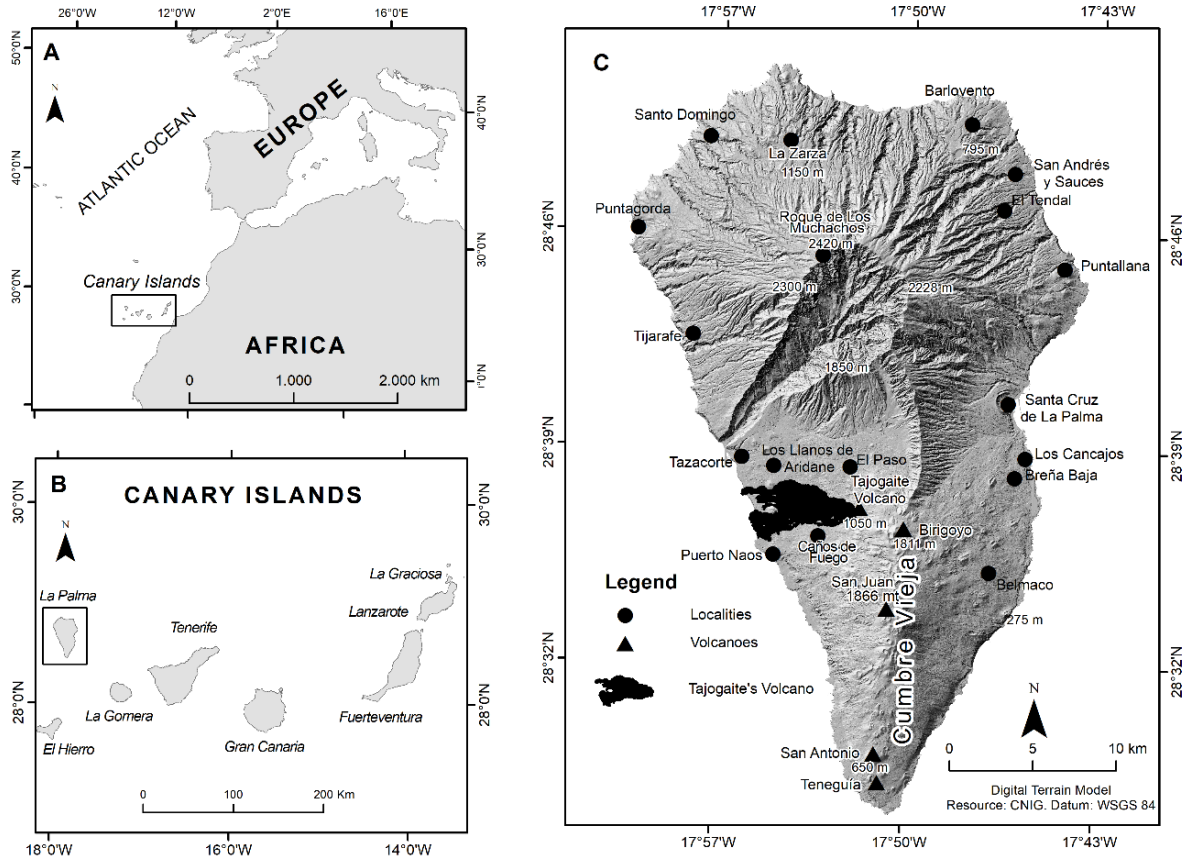

Figure 1. A – Location of Canary Islands. B – Canarian Archipelago. C – La Palma study area
Source: prepared by the authors, based on Grafcan

edifice (Barrera Morate & García Moral 2011). Finally, volcanic activity migrated towards the south of the island, with the formation of the Cumbre Vieja edifice, some 0.12 Ma (Carracedo et al. 2001). This is now the active volcanic area where all the historic eruptions of La Palma have taken place.

Methodology

The methodology applied in this study was divided into three stages to assess geotourism before, during and after the eruption of the Tajogaite Volcano. In the first stage, prior to September 2021, a review of the literature on topics related to tourism and, more specifically, to geotourism in La Palma was carried out. In this first phase, several field campaigns were organised as part of the Volturmac project in 2020 and 2021 to assess the volcanic heritage resources of the island that were being exploited from a tourism point of view; various sites of geotourism interest were identified.

In the second stage, which covered the period of the Tajogaite eruption from September to December 2021, a survey was conducted *in situ* and online, in Spanish and English, and using Google Docs, to assess the interest of the eruption for tourism; respondents were limited to visitors who had witnessed the volcanic eruption on the island first-hand. The survey was divided into three sections: visitor profile, tourism on the island and the volcanic eruption.

The third stage covered the years 2022 and 2023 and was linked to the La Palma Island Recovery Project, which was commissioned by the governments of Spain and the Canary Islands. During this stage, sites of geotourism interest in natural and/or urban areas, associated with the Aridane Valley in general and the Tajogaite Volcano in particular, were identified, selected and evaluated for the development of geotrail proposals. Reference is also made in this paper to other measures that are being developed on the island that go beyond the main aim of this study.

Results and Discussion

The Canary Islands Tourism Observatory published a recent report on sustainable tourism in the Canary Islands, in which it stated that 21.5% of tourists that came to the islands in 2022 were willing to choose sustainable options for their trip (Hernández & León-González 2023). This amounts to more than three million tourists, given that more than 14 million visited the Canary Islands in 2022 (Istac 2023). This should not come as a surprise if we take into account, on the one hand, the new global trend of demand for increasingly discerning, informed and sustainable tourism and, on the other hand, the type of tourism on offer in the Canary Islands, which have been committed to sustainable products and experiences for many years.

Geotourism on the island of La Palma before the 2021 volcanic eruption

Before tourism became one of the main economic activities on the island, an incipient geotourism industry was already being developed in connection with the volcanic eruptions of San Juan and Teneguía. Those who came to view these volcanoes were known as 'fire tourists' (Actualidad Española 1971). This is evidence of the importance of geotourism activities

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Figure 2. Tajogaite monogenetic eruption, 2021, La Palma
Source: authors

associated with volcanic eruptions on La Palma, even though this was not explicitly called geotourism. Activities linked to hiking, volcanoes, archaeology and stargazing are of particular note (Pais Pais 2020, Fernández-Hernández et al. 2022, Hernández et al. 2022). La Palma boasts a large and well-marked network of trails through the main natural and cultural volcanic landscapes of the island, and several interpretation centres devoted to volcanoes (San Antonio Volcano, Caños de Fuego and Roque de Los Muchachos) and archaeology (El Tendal Archaeological Park, Belmaco Archaeological Park, and La Zarza and La Zarcita). It is also a Starlight Reserve and Starlight Tourist Destination, with numerous stargazing sites all over the island.

Geotourism during the 2021 volcanic eruption

Without a doubt, the volcanic eruption of Tajogaite was, despite the negative impacts on people, property, equipment and infrastructures, a tourist attraction for the island of La Palma during the months it lasted (Dóniz-Páez et al. 2024). The opportunity to see a live eruption is one of the main reasons for visiting a volcano (Sigurdsson & Lopes 2000) (Fig. 2). This is why the natural spectacle offered by volcanic eruptions was a major draw for visitors and sightseers in the last three historic eruptions on La Palma in 1949, 1971 and 2021. However, in the first few days following the onset of the volcanic eruption, the number of visitors to the island fell sharply. This was due to the direct effects of the eruption: the destruction of tourist accommodation, the evacuation and closure of the tourist resort of Puerto Naos, intermittent closures of the airport, and uncertainty as to what was going to happen. From October onwards, as the eruption continued, the number of visitors increased – aided by public holidays and the positive attitude towards viewing an eruption among tourists and locals – so much so, that the island authorities predicted that the island would be overwhelmed by up to 30,000 visitors in one weekend (El País 2021), but these figures are not official. From December onwards, the number of visitors dropped again, as the eruption came to an end (Fig. 3).

To assess the value of this eruption for tourism, a survey was conducted from September to December 2021 to determine the profile of visitors and the importance of the eruption for tourism on the island. A total of 752 surveys were completed, both directly on the island and online using Google Docs; they were distributed through Facebook, Instagram, Twitter (now X), WhatsApp and the Volturmac project website (Volturmac 2021). Of the total number of surveys, 60.24% were conducted online and 39.76% face to face.

In the surveys, visitors were asked for the following information: age (<20, 20–30, 31–40, 41–50, 51–60 and >60), level of studies (no studies, primary, secondary, university), professional status (student, unemployed, working, retired) and nationality/origin (international, national, local).

According to the survey, visitors who came to see the eruption were primarily between the ages of 41 and 50 (26.8%), with a university education (72.6%), in employment (76%) and of local origin (>70%), mostly from the island of Tenerife (>60%), followed by the rest of the Canary Islands and the rest of Spain; international tourism was poorly represented. These data point to more mature, educated visitors with an interest in volcanic heritage – in line with the sustainable profile of the geotourist.

Regarding the tourism potential of La Palma, respondents were asked: whether it was the first time they had travelled to

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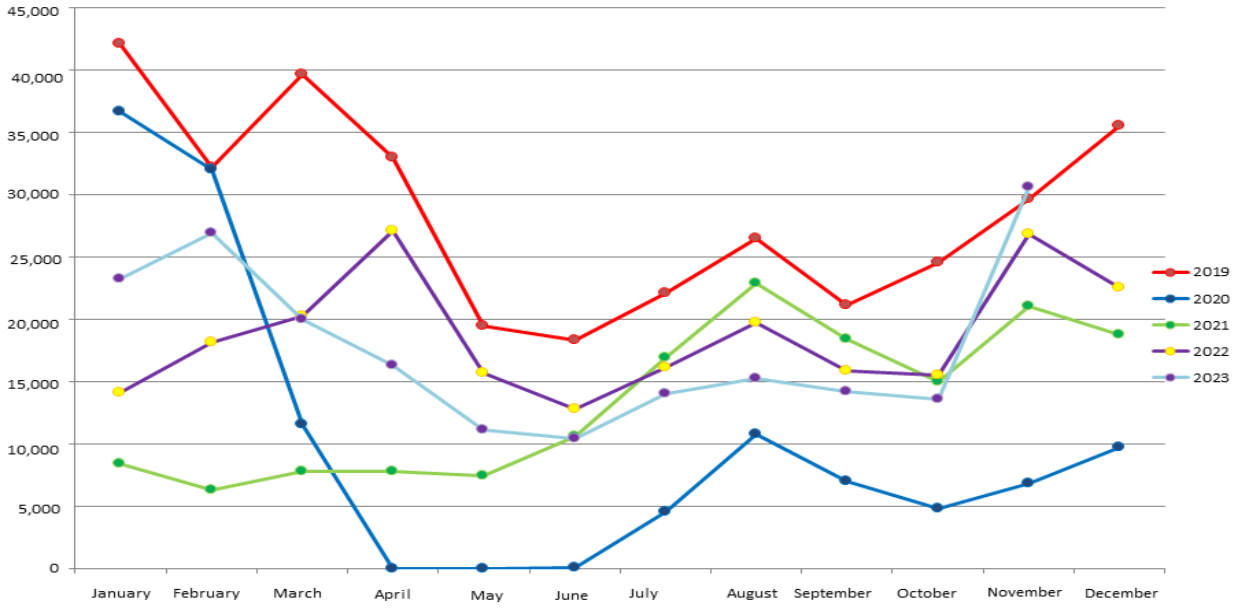

Figure 3. Evolution of the number of visitors to La Palma. Source: IS-185 Istac, 2023
Prepared by the authors

La Palma and how many times they had visited; what means of transport they used to get there (boat or airplane); with whom they visited the island (alone, as a couple, with family, with friends, other); where they stayed (hotel, apartment, rural house, family or friend's house, other); in which municipality they stayed; which month they visited (September, October, November, December) and how long they stayed on the island (<1 day, 1–2 days, 3–5 days, 6–7 days and >7 days). The data obtained from the survey show that only 10% of the respondents were first-time visitors to La Palma, compared with 90% who had visited more than once, which is in keeping with the fact that the majority of visitors came from the other islands, given their geographical proximity, and the difficulty in reaching La Palma during the months when the eruption was taking place. Some 75.7% arrived on the island by boat and 24.3% by plane, which is not surprising given the high number of days during the eruption that the airport was closed due to ash fall. When asked with whom they had visited the island, 33.2% went with friends, followed by family (32.9%), a partner (26.1%), and 7.8% went alone. The most common types of accommodation were hotels (26.9%) and apartments (26.9%), followed by the house of a relative or friend (15.1%) or a rural house (12.2%); it is striking that the remaining 18.9% stayed in caravans or in their own vehicles. As for the municipalities where they stayed, 29.1% stayed in one of the three towns (El Paso, Los Llanos de Aridane, Tazacorte) directly affected by the volcano, while the remaining 70.9% stayed in towns that were not directly affected by the lava flows, including the island's capital Santa Cruz de La Palma (20.6%) and the tourist town of Breña Baja (20.1%). As regards the month in which they visited the island, the majority did so in October (50%), followed by November (33%), September (11.8%) and December (5.2%), which is in line with figure 2 above. In terms of time spent on La Palma, the majority (43.7%) stayed between 1 and 2 days, followed by those who stayed between 3 and 5 days (31.5%); similar percentages stayed less than a day (8.6%), a week (8.1%) and more than 7 days (8.1%).

Lastly, in relation to the importance of the island for tourism, they were asked specifically about the reasons that led them to visit La Palma during the eruption (volcanic eruption, landscapes, beaches, cuisine, shopping, people, other). In this case the respondents could select multiple items. Of the 1,026 responses, 660 (64.3%) chose volcanic eruption, followed by landscapes (11.3%), unspecified other (10.8%), cuisine (6.1%), people (4%), shopping (2%) and, lastly, beaches, which only accounted for 1.5% of the responses. This is in keeping with La Palma's alternative tourism strategy, and with the fact that the island's main sun-and-beach resort (Puerto Naos) was evacuated and had remained closed since the beginning of the eruption, although it is now partially reopening. Therefore, these percentages show that the volcano was La Palma's main tourist attraction during the months when it was erupting.

They were also asked specifically about the most striking features of the volcanic eruption (noise, fire, smell, ash fall, effects/damage, other). Again, multiple answers were permitted, and we obtained 1,607 responses. The most striking features of the volcanic eruption were reported to be noise (26%), ash fall (22.5%), impact and damage to people and their belongings (18.9%), fire (17.5%), smell (10.6%) and, finally, other (4.5%), which was not specified. These data are not surprising since, throughout the history of eruptions in the Canary Islands, noise has always been recorded in chronicles as one of the most striking aspects for the local population. Similarly, in the case of the Tajogaite eruption, one of the most striking impacts was the heavy ash fall, which even reached other islands, covering the landscape and darkening the skies for many days, making daily life difficult for the inhabitants of the Aridane Valley and causing the closure of the airport. With regard to the impact and damage to people and their belongings, the fact that this aspect attracted so much attention is not surprising since Tajogaite had enormous negative impacts and is considered the most destructive eruption in Europe in the last 75 years (Canarias7 2023); the impacts are still very evident today. Also of note is the importance given by respondents to the fire of the eruption, especially at night, when it became a spectacle for tourists, leading certain companies from other islands to organise one-day tours to the island to spend a night watching the eruption from different locations and to return the following day.

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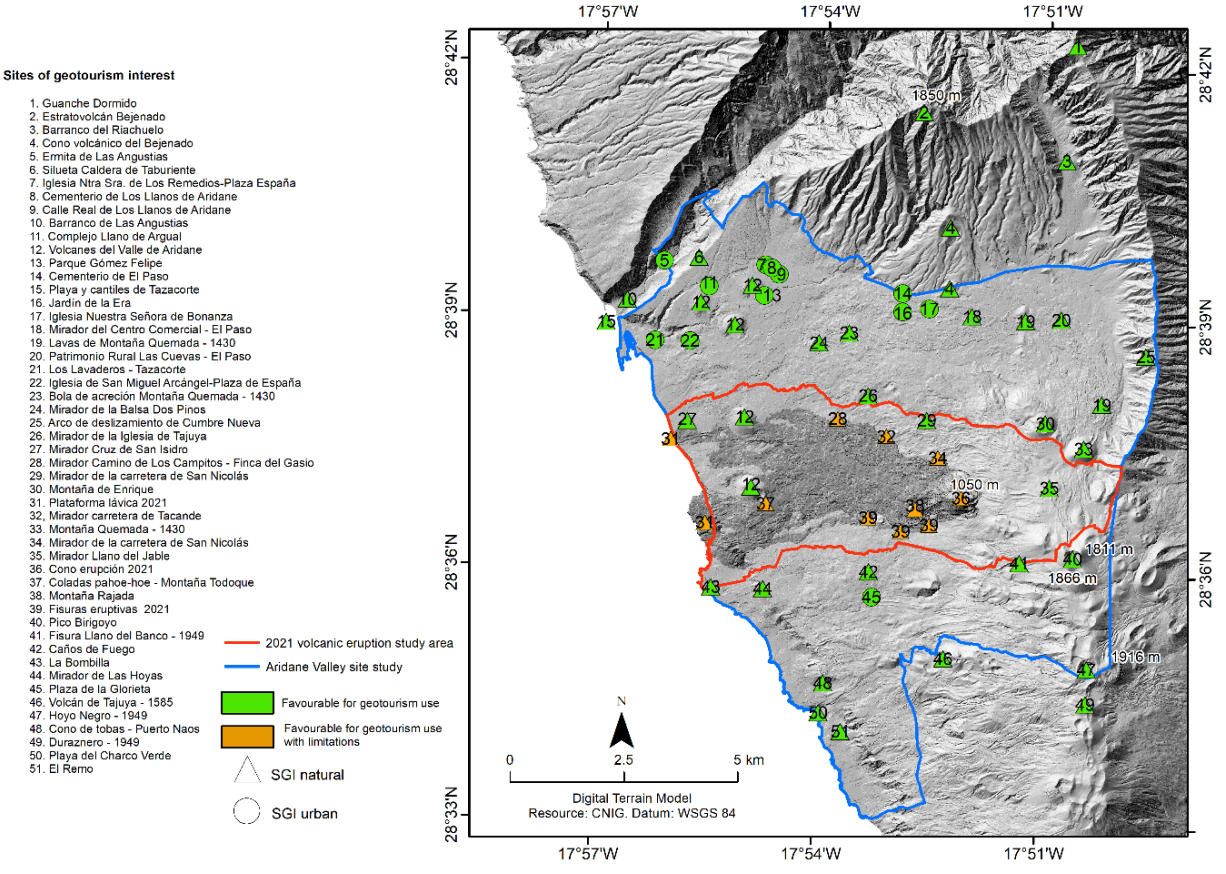

Figure 4. Sites of geotourism interest, natural and urban, in the Aridane Valley and its surroundings
Source: prepared by the authors based on Grafcan

Geotourism after the 2021 volcanic eruption

Once the eruption ended, different public administrations implemented the La Palma Island Recovery Plan and the La Palma Renace Plan. The former included multiple actions related to the sectors directly affected by the eruption (urban planning, agriculture, tourism, etc.) and the latter exclusively focused on measures to reactivate tourism on the island through the granting of €5.6 million in tourist vouchers for domestic tourists to travel to La Palma during 2022 (La Moncloa 2022). Among the actions developed in the La Palma Island Recovery Plan, of interest to this study, are those related to tourism, which was one of the activities that suffered the most during and after the volcanic eruption, but also because it is one of the great assets for the economic and social recovery of the island – so much so that the Spanish government stated that the two great opportunities for the post-eruption regeneration of La Palma were geothermal energy and volcanic tourism (Gutiérrez 2022). Therefore, it is understandable that the State and regional governments were committed to actions aimed at identifying and cataloguing the geodiversity of the volcanic geoheritage of the Tajogaite cinder cone and the sites of geotourism interest in the Aridane Valley. To this end, several field campaigns were carried out during which an inventory was drawn up of the natural and cultural heritage of geotourism interest associated with the Tajogaite eruption, in addition to its heritage prior to the eruption. In total 51 sites of geotourism interest were selected, of which 76.5% were natural and 23.5% urban; these were divided into two specific areas (Tajogaite eruption and Aridane Valley) and grouped in two categories: favourable for geotourism use and favourable for geotourism use with limitations (Fig. 4).

In addition to the creation of the geotourism map of the Aridane Valley and its surroundings, other actions were implemented to promote geotourism activities. These included geotourism courses for active tourism company guides and the proposal to identify geomorphosites when designing *in situ* and virtual geotrails for both the Aridane Valley and the Tajogaite Volcano, based on regular fieldwork, videos and drone flights during and after the eruption (Dóniz-Páez et al. 2024).

It is clear that these actions had clear geotourism-related precursors, linked to the landscapes and heritage of the volcanoes of La Palma, in particular the historical eruptions of San Antonio (1676–77), San Juan (1949) and Teneguía (1971). At the same time, they include other current developments around the volcano, such as the creation of a guided footpath leading to the Tajogaite volcanic edifice, the creation of viewpoints and tourist information points explaining the volcanic eruption, and the creation of the Cumbre Vieja Volcano visitor centre and virtual reality interpretation centre, which was presented at the International Tourism Fair – FITUR 2024 (El Diario 2024). Geotourism initiatives have also been developed on the island as a whole, including an inventory of sites of geotourism interest on La Palma and the design of urban geotrails in the island's two main towns (Santa Cruz de La Palma and Los Llanos de Aridane).

Final remarks and recommendations

The eruption and formation of the Tajogaite Volcano played a dual role for the island of La Palma. On the one hand, it caused considerable damage for the population, bringing it to the world's

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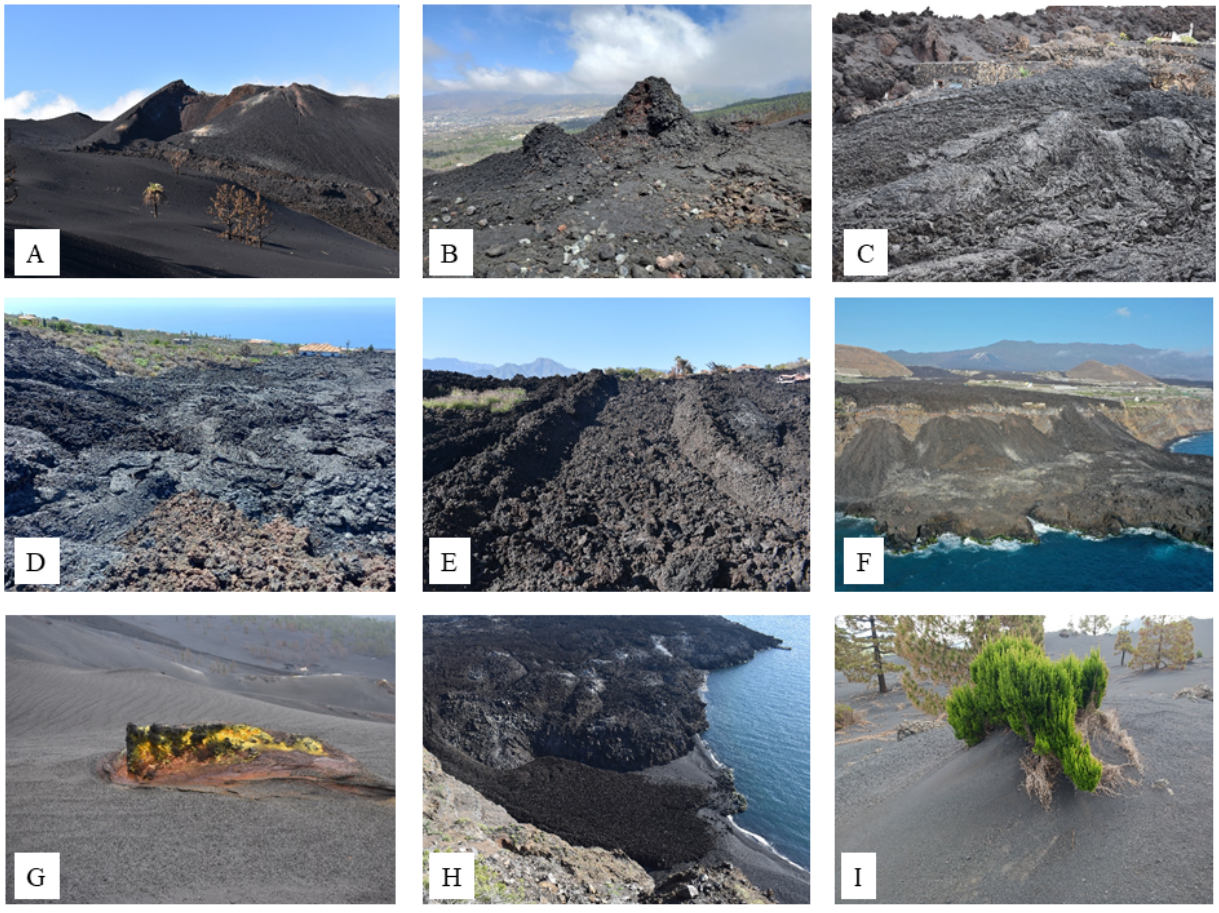

Figure 5. Geoforms generated by the Tajogaite eruption. A – cinder cone. B – hornitos spatter. C – effusive fissure. D – pahoehoe lava flows. D – aa lava channel. F – lava delta. G – lapilli field. H – beaches. I – lapilli dunes
Source: authors and R. Gosálvez (photo F)

attention as the most destructive eruption in Europe in the last 75 years. On the other hand, Tajogaite was a real-time laboratory for a multitude of scientific disciplines, leading to a wide range of volcanological studies to be developed and conducted during the three months of the eruption. At the same time, it became a tourist attraction, drawing thousands of visitors and curious onlookers to witness the spectacle of a live eruption.

This study has focused on analysing the opportunities offered by volcanic landscapes from a geotourism point of view. To this end, the tourist attraction that was the Tajogaite eruption in La Palma was taken as a starting point, and the importance of geotourism before, during and after the eruption was assessed based on the recognition of tourism products and experiences, and of facilities and services linked to the island's volcanic heritage.

The analysis showed that the main tourism activities on the island prior to the eruption (hiking, volcanoes, archaeology, stargazing) all fell within the scope of sustainable tourism, with volcanoes playing a prominent role in shaping and developing these activities. For this reason, there is a comprehensive and well-marked network of trails that run through the most spectacular volcanic landscapes on the island, such as the Caldera de Taburiente and the Volcanoes Route; there are also several interpretation centres associated with volcanism and *in situ* archaeological remains and numerous strategically located astronomical viewpoints.

Today, no one can deny the prominent role played by the eruption in attracting thousands of visitors, onlookers and scientists who came to the island during the three months of the process to observe a live volcano or to carry out numerous scientific studies. Whatever the negative impacts the eruption caused, and continue to cause, for the island's society, the images of the volcano travelled around the world; one such photo, taken by an astronaut on the ISS, even won NASA's 2022 Tournament Earth competition. Therefore, the 752 surveys carried out during this time show the appeal and interest in this spectacle of nature.

After the eruption and given the interest it aroused from a tourism point of view, the different administrations made a firm commitment in their plans and projects to evaluate the geotourism potential of the new landscape generated by Tajogaite (Fig. 5). To this end, various initiatives were launched to identify and evaluate the diversity of the natural heritage, to select sites of geotourism interest, to provide training courses to tour guides and to create trails and viewpoints to see the new volcano and its lava field. Another aim was to ensure that all these actions could be combined with existing, highly similar, activities on La Palma, such as those related to the San Juan and Teneguía volcanoes.

It is clear that the natural and cultural heritage associated with volcanoes, the main justification for the geographical approach of geotourism, has always played an important role in the sustainable and distinctive tourism model of La Palma. For this reason, efforts must continue in this direction so that

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La Palma can consolidate its strategic position and become one of the world's leading volcanic tourism destinations. A firm commitment must therefore be made, both by the authorities and society, to conserve and maintain, in the long term, the natural and cultural volcanic heritage on which geotourism is based.

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