proceedings

MDPI

Proceeding Paper

Tajogaite 2021 Eruption (La Palma, Canary Islands, Spain): An Exceptional Volcanic Heritage to Develop Geotourism †

Javier Dóniz-Páez [1,2,*], Károly Németh [3,4,5], Rafael Becerra-Ramírez [1,2,6], William Hernández [1], Rafael U. Gosálvez [1,6], Estela Escobar [1,6] and Elena González [1,6]

1 Instituto Volcanológico de Canarias (INVOLCAN), 38320 San Cristóbal de La Laguna, Spain; rafael.becerra@uclm.es (R.B.-R.); william.hernandez@involcan.org (W.H.); rafaelu.gosalvez@uclm.es (R.U.G.); estela.escobar@uclm.es (E.E.); elena.gonzalez@uclm.es (E.G.)
2 Grupo de Geopatrimonio y Geoturismo en Espacios Volcánicos, GeoTurVol-Departamento de Geografía e Historia, Facultad de Humanidades, Universidad de La Laguna, C/Prof. José Luis Moreno Becerra, s/n, 38200 San Cristóbal de La Laguna, Spain
3 School of Agriculture and Environment, Massey University, Palmerston North 4442, New Zealand; k.nemeth@massey.ac.nz
4 Lithosphere Physics Research Group, Institute of Earth Physics and Space Science, 9400 Sopron, Hungary
5 The Geoconservation Trust Aotearoa Pacific, Opōtiki 3122, New Zealand
6 GEOVOL, Department Geography and Land Planning, Facultad de Letras, Universidad de Castilla-La Mancha, 13001 Ciudad Real, Spain
* Correspondence: jdoniz@ull.edu.es

† Presented at the 4th International Electronic Conference on Geosciences, 1–15 December 2022; Available online: https://sciforum.net/event/IECG2022.

Abstract: In the Canary Islands, sixteen historical eruptions have been documented in Lanzarote, Tenerife, El Hierro, and La Palma. The latest eruption, the Tajogaite eruption, occurred in 2021 in La Palma and the richness and diversity of the natural and cultural heritage associated with this eruption can be a valuable resource for attracting visitors and tourists. The main aim of this work is to select sites of geotourist interest (SGIs) in order to create geo-itineraries. The methodology used is based on fieldwork and drone flight videos and photos taken during and after the eruption. Sixteen SGIs have been selected and studied. Eleven sites represent the geo-heritage of the Tajogaite eruption and seven sites are related to the surrounding natural and rural landscapes. In the near future, geo-itineraries (for in-person and virtual visits) will be created for visitors to La Palma and for the interested online audience.

Keywords: volcanic heritage; geotourism; sites of geoturistic interest; geo-itineraries; Tajogaite; La Palma; Spain

check for updates

Citation: Dóniz-Páez, J.; Németh, K.; Becerra-Ramírez, R.; Hernández, W.; Gosálvez, R.U.; Escobar, E.; González, E. Tajogaite 2021 Eruption (La Palma, Canary Islands, Spain): An Exceptional Volcanic Heritage to Develop Geotourism. *Proceedings* **2023**, *87*, 26. https://doi.org/10.3390/IECG2022-13748

Academic Editor: Karoly Nemeth

Published: 30 November 2022

1. Introduction

Volcanic eruptions have huge direct and indirect territorial implications both during and after the eruption process. Given the large footprint they create, the impacts of a volcanic eruption are commonly negatively assessed as threats, hazards, and risks. However, volcanic eruptions can also have positive impacts through the provision of strengths and opportunities for the society to be resilient against natural hazards. Volcanic landscapes offer multiple attractions for the population that coexist with them. Millions of people live in areas with active volcanoes [1,2], and their most important contributions include fertile soils for agriculture, geothermal energy, and materials for construction and tourism activities [3]. For tourism, the diversity of natural and cultural heritage associated with volcanoes can serve as a major attraction [4,5]. Previous studies have identified the resources offered by volcanoes for the development of volcano-tourism [6,7] into eight categories: scenery, the spectacle of volcanic activity, hot springs and spas, climbing and skiing on volcanoes, ecology and adventure travel, black, red, and green sand beaches, and archaeology and religion [8].

In the case of the Tajogaite volcano, its eruption has caused huge damage to the local population, equipment, infrastructure, and economic activities, with especially negative effects on agriculture and tourism [9]. However, the eruptive phenomenon and the new landscapes generated by the eruption demonstrate potential as new attractions for geotourism [10–14]. Therefore, the main aim of this work is to select sites of geotourist interest (SGIs) associated with the heritage of the Tajogaite eruption and surrounding volcanic landscapes in La Palma island in order to create real or virtual geo-itineraries in the near future. The use of the concept "sites of geotourist interest" is based on the research of Kubalíková et al. [15,16] which states that, for the purposes of geotourism, both geosites/geomorphosites *sensu stricto* and other types of sites can be considered.

2. Materials and Methods

2.1. Study Area

The Canary Islands are eight Spanish islands located off the west coast of Africa (Figure 1). The main economic activity is tourism, with an average of around 15 million tourists per year [17]. The Canary Islands are volcanic islands with active volcanism under subtropical oceanic climate. Sixteen eruptions have been documented in historical times on Lanzarote (1730–1736 and 1824), Tenerife (1492, 1704-1705, 1706, 1798, and 1909), El Hierro (2011–2012), and La Palma (1480, 1585, 1646, 1677, 1712, 1949, 1971, and 2021). The last eruption occurred between 19 September and 13 December 2021 in the Cumbre Vieja volcanic rift (CVVR) on La Palma Island (Figure 1).

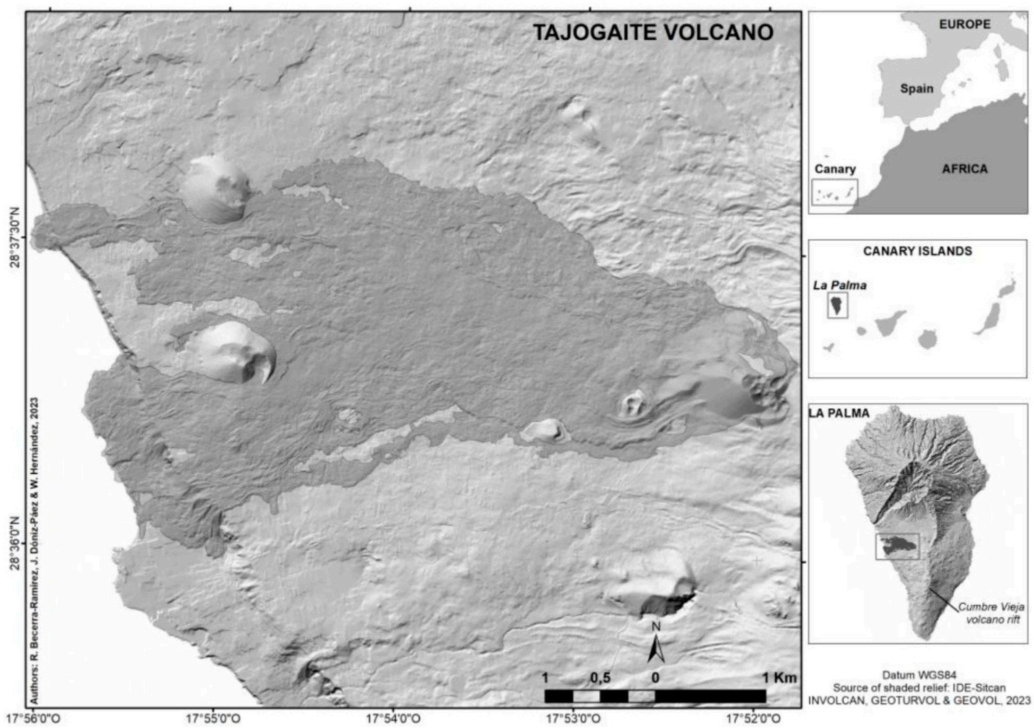

Figure 1. Location of the Tajogaite volcano. Spatial data source [18,19]. Self-elaboration.

The CVVR is one of the principal geologic and geomorphologic units of La Palma. This rift has a gable roof shape, elongated in a N–S direction, with a length of about 20 km, an altitude of 1950 m meters, and an extension of more than 220 km^2. During the last 150 ky, eruptive activity has been concentrated in this part of La Palma [19], making it the most recent geological unit on the island with eight historical eruptions. The axis of CVVR is the location of most Holocene volcanic cones (cinder cones, phonolitic domes, spatter cones) and eruptive fissures, and the ridges are dominated by piles of pahoehoe and aa lava flows from the volcanic cones located on this axis. In the coastal area, lava deltas are formed by lava flows jumping over a former cliff. Generally, the CVVR eruptions are basaltic, and fissural, with dynamics ranging from Strombolian explosive/effusive to phreato-Strombolian [20]. The forms and processes of erosion and accumulation are associated with the presence of some gullies, fossil and active cliffs, alluvial and colluvial deposits, dunes, and the formation of small beaches [21].

Due to the high altitude (>1940) of CVVR, a wide variety of plant ecosystems are found, corresponding to the different altitudinal belts of the island. Plant species identified in this area include the Canarian xerophytic scrub and shrublands (*Euphorbia canariensis, Euphorbia balsamífera, Rumex lunaria, Euphorbia lamarckii, Bituminaria bituminosa, Kleinia neriifolia*), juniper woodland (*Juniperus turbinata subsp. canariensis*), some enclaves of laurel forests (*Myrica faya, Erica arbórea* . . .), and the Canary pine forests (*Pinus canariensis*) which are predominant along the entire axis and most of the slopes of the CVVR.

The inhabitants of La Palma have occupied this area from pre-Hispanic times to the present day and, throughout history, they have taken advantage of the diversity of the natural resources offered by ancient and recent volcanic landscapes. The rural to periurban settlement of the island is dispersed, with preferences for locations with fewer areas of steep topography such as the Valle de Aridane where the eruption occurred. Examples of rich cultural heritage that utilise the volcanic landscapes include the construction of traditional stone houses, traditional livestock farming, and agricultural practices, both traditional agriculture and market agriculture for export.

2.2. Fieldwork and Drone Flights Videos and Photos

Several fieldwork campaigns have been conducted during the years 2021 and 2022 since the beginning of the eruption, after the eruption, and during the "return to normality" recovery work phase, which is currently underway in affected areas. During the fieldwork campaigns, information was collected on the natural and cultural heritage of geotourism interest before the volcanic eruption, as well as those on that which was generated during or after the eruption. All the information obtained was collected in a field card [3] facilitating the identification and characterization of the natural and cultural heritage of the SGIs. Furthermore, during the eruption, several videos were recorded on eruptive styles (eruptive column, ash fall, cone collapse, lava flows, contact water–lava flows, etc.) and the formation of volcanic geoforms (cinder cones, craters, lava shatter rings, flows, lava tubes, lava channels, lava falls, lava delta, etc.). Once the eruption was over, several drone flights (DJI Mavic 2 Pro with camera Hasselblad) were carried out to take photographs and videos, enabling us to select and characterize the most representative SGIs for both natural and cultural heritage. This heritage is directly associated with the Tajogaite eruption and with the volcanic landscapes around the volcano and will form the basis of creating real or virtual geo-itineraries soon.

3. Results

The Tajogaite eruption is located on the west flank of the CVVR in the area known as Cabeza de Vaca. It is a fissural eruption that opened between 840 and 1100 m.a.s.l. [22]. Several parallel fissures of NNW–SSW direction could be identified [23], with several aligning vents. The eruptive dynamics comprised Strombolian style explosions with eruptive columns varying from a minimum of a few hundred meters to a maximum of 8 km, as well as Hawaiian phases with lava fountains several hundred meters high [22,23]. Several pyroclastic density currents (PDC) associated with the collapse of the volcanic edifice were formed during the eruption [22]. The erupted products consisted mainly of lava and tephra of tephrite/basanite bulk composition [23]. The main volcanic geoforms are associated with the formation of volcanic edifices and lava fields. The former includes one fissural scoria cone about 200 m high and 800 m in diameter with a volume of 36.5 ± 0.3 Mm^3, a surface of 0.6 km^2 [19,24] and at least 9 main craters. Multiple hornitos have also been built at the northern base of the main edifice, and various effusion lava vents [25] that run from the east of the San Nicolás road to Las Norias along a length of 1.9 km. The lava surfaces covered an area of more than 12 km^2 [23] and are characterized by their morphological diversity. Aa, pahoehoe, blocks and balls lava flows, lava deltas, lava tubes, channels, shatter rings, jameos (collapsed lava tunnel), etc. can be recognized.

Sixteen SGIs on volcanic forms created by the Tajogaite eruption as well as sites in surrounding areas have been selected and studied (Figure 2 and Table 1), given the high geodiversity of the main edifice, minor secondary edifices, and the multiple lava flows emitted by the eruption. SGIs in this study include the geoheritage of the Tajogaite volcano (scoria cones, hornitos, fissures, lapilli and ash fields, lava fields, lava deltas, lava tubes, lava channels, jameos, paleo-cliffs, gullies, slopes, sedimentary deposits, cliffs, and beaches) (Figure 3) and natural (lava field and pine forest) and rural elements (traditional houses, stone walls, crops, and livestock) (Figure 4) of the area.

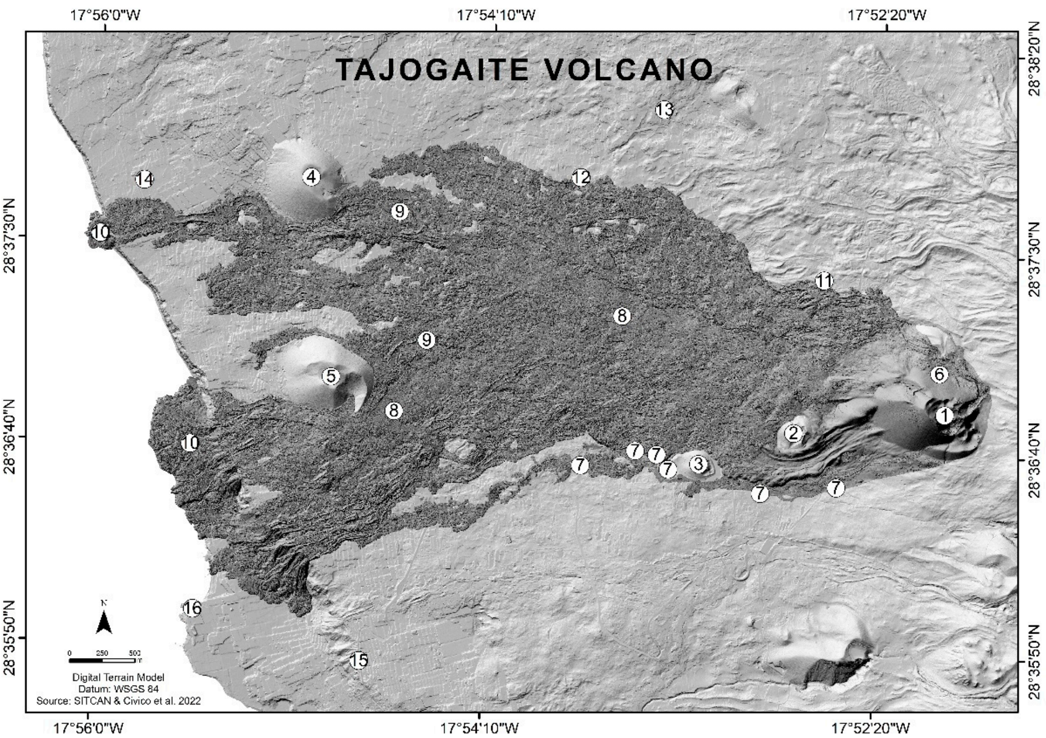

Figure 2. Location of the SGIs associated with the Tajogaite volcano. The numbers are listed in the Table 1. Spatial data source: [18,19]. Self-elaboration.

Table 1. The heritage of the sixteen SGIs selected. Self-elaboration.

Nº	SGI	Natural Heritage	Cultural Heritage
1	Tajogaite cone 2021	Cinder cone, craters, lavas, ash, lapilli, bombs, impact craters, gases, sulphur concretions, taluses, ripples, debris flows, pines forest, fauna (birds)	Valle de Aridane panoramic views
2	Rajada Mountain	Cinder cone, lava flows, lapilli, gases, ripples, pines, fauna (birds and Gallot's Lizards)	Houses, crops, stone walls
3	Cogote Mountain	Cinder cone, lava, lapilli, ravines, taluses, xeric scrub, fauna (birds and Gallot's Lizards)	Houses, cemetery, crops, stones walls, quarries
4	La Laguna Mountain	Cinder cone, lava, lapilli, ravines, xeric scrub, fauna (birds and Gallot's Lizards)	Houses, paths, greenhouse crops, stones walls, quarries, archaeological sites

Table 1. *Cont.*

Nº	SGI	Natural Heritage	Cultural Heritage
5	Todoque Mountain	Cinder cone, pahoehoe lava, lava channels, ravines, xeric scrub, fauna (birds and Gallot's Lizards)	Paths, greenhouse crops, archaeological sites
6	Hornitos 2021	Hornitos, scoria cones, lava lake, pahoehoe lava, jameos, lava tubes and channels, accretion balls, collapses, lapilli, ripples, impact craters, taluses, pines	Crops, buried stones wall
7	Fissures 2021	Fissures, scoria cones, hornitos, pahoehoe lava, lava tubes and channels, jameos, gases, pines, xeric scrub	Houses, cemetery, crops, buried stones wall
8	Pahoehoe lavas 2021	Lava field, lava tubes and channels, jameos, slaps, collapses, cinder cone, birds	Roads, houses under the lava
9	Aa lavas 2021	Lava field, aa, blocks and balls lava, lava channel, accretion balls, xeric scrubs, pine forest, birds	Houses, paths, crops, livestock, buried stones wall, archaeological sites
10	Lava delta 2021	Lava delta, taluses, channel, beaches, cliffs, seabirds	Road
11	Tacande viewpoint	Panoramic 2021 lava flows, lava channels, accretion balls, cinder cones, xeric scrubs, pine forests, fauna	Crops, paths, traditional houses
12	Campitos viewpoint	Lava flows, xeric scrubs, fauna	Crops, stone wall, roads, houses
13	Tajuya Church	Tajogaite panoramic views, Cumbre Vieja rift, cinder cones, lava flows, xeric scrubs, pine forest	Village, Church, crops, paths
14	San Isidro viewpoint	Lava flows, cinder cones	Greenhouse crops, hermitage
15	Hoya viewpoint	Lava delta, taluses, ravines, xeric scrubs, fauna	Greenhouse crops, houses, roads
16	Bombilla lighthouse	Lava delta, cliffs, ravines, beaches, xeric scrubs, seabirds	Lighthouse, greenhouse crops

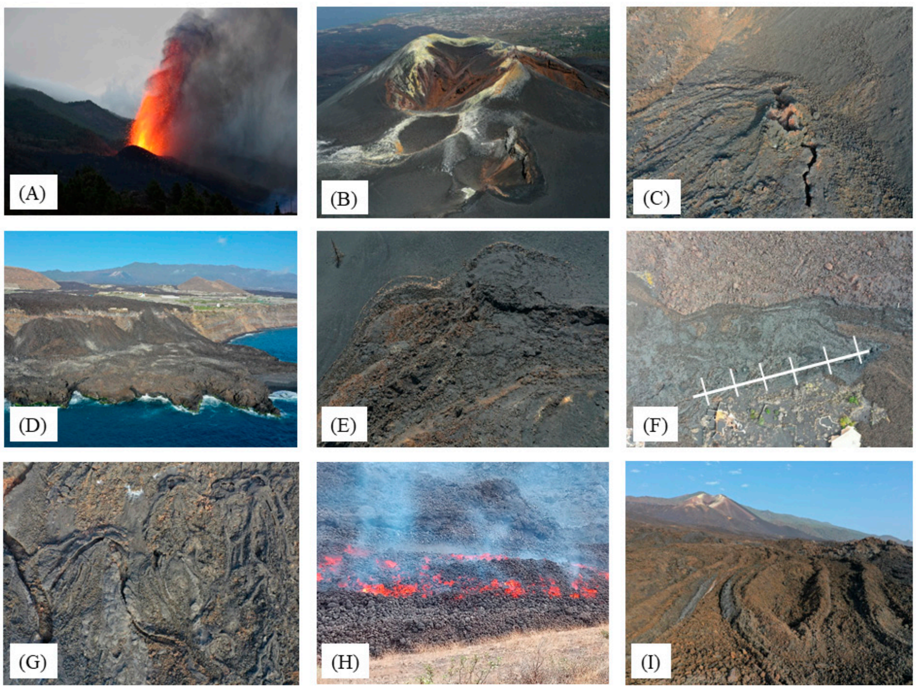

Figure 3. Geoheritage of Tajogaite eruption. Eruptive column one day after the onset of eruption (20 September 2021) (**A**), different craters (**B**), hornitos and lava tube (**C**), north lava delta (**D**), lava lake and lava channels (**E**), eruptive fissure with hornitos and pahoehoe lava flows (**F**), aerial photo of pahoehoe lava fields and lava tubes (**G**), active aa lava flow (23 November 2021) (**H**) cinder cone and lava channels (**I**).

Figure 4. Cultural heritage of Tajogaite eruption. Traditional houses (**A**), pathways (**B**), traditional vineyards (**C**), stone walls (**D**), banana greenhouse crops (**E**), artificial ponds for crops (**F**), house under lava flows (**G**), doors molds (**H**) and gardens under lava flows (**I**).

4. Discussion

Volcanic eruptions and the landscapes they generate are a geoheritage that demonstrates a natural spectacle with high geodiversity [4], which provides multiple tourist resources [6–8]. In the case of the Tajogaite volcano, thousands of visitors came to La Palma to observe its eruption [13,14]. After the eruption ended, thousands of tourists continued to visit the island to observe the volcano and its effects on the landscape and the territory. In fact, it became one of the main tourist attractions of La Palma in 2022 [26] (Figure 5). However, more time is required to accurately assess the effect that this eruption will have on the tourism of La Palma.

This eruption is unique, compared to the other historical eruptions in the Canary Islands, in that the entire growth of the Tajogaite monogenetic volcano has been monitored from its beginning to its end, which has provided valuable information for different scientific disciplines, including volcanic tourism. In this sense, we have important documentation on the formation and evolution of the eruption, its geoheritage, and its territorial effects. This fact turns the eruption into a laboratory to identify, select, and characterize sites of geotourism interest associated with the natural and cultural heritage created and destroyed during and after the eruption. In addition, virtual and augmented reality [27,28] can be applied to create geotourism products associated with the eruption event. For this reason, the selection of these important geotourism sites could contribute to the sustainable local development of La Palma through both in situ and virtual geo-itineraries, as with those that have been produced in other volcanic areas [28–30].

This study highlighted the rich and varied heritage associated with the eruptive event at Tajogaite and the current tourist demand that exists in visiting the volcano along with its territorial impacts. The identification, selection, and characterization of SGIs are more than justified as they respond to the demand for volcano tourism. It is necessary to propose the creation of virtual or real geo-itineraries, taking advantage of the selected SGIs, to show the exceptional volcanic heritage created through this eruption. This development undoubtedly enriches the geotourism sector, not only in the area affected by the eruption, but throughout the island of La Palma.

Figure 5. Visitors and tourists during (**A**–**G**) and after (**H**,**I**) the Tajogaite eruption.

Author Contributions: Conceptualization, J.D.-P. and R.B.-R.; methodology, J.D.-P., R.B.-R. and R.U.G.; Drone flights R.U.G.; software, W.H. and R.B.-R.; validation, W.H., R.B.-R. and R.U.G.; formal analysis, J.D.-P., R.B.-R., R.U.G., E.E. and E.G. investigation, J.D.-P., K.N., R.B.-R., R.U.G., E.E. and E.G.; resources, J.D.-P. and R.B.-R.; data curation, J.D.-P.; writing—original draft preparation, J.D.-P. and R.B.-R.; writing—review and editing, J.D.-P., R.B.-R. and K.N.; visualization, K.N.; supervision, J.D.-P. and K.N.; project administration, J.D.-P. and R.B.-R.; funding acquisition, J.D.-P. and R.B.-R. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Administración General del Estado-Ministerio de Ciencia e Innovación, Ministerio para la Transición Ecológica y el Reto Demográfico del Gobierno de España and the Consejería de Transición Ecológica, Lucha Contra el Cambio Climático y Planificación Territorial del Gobierno de Canarias-GESPLAN. Project "VOLTURMAC, Fortalecimiento del volcano turismo en la Macaronesia (MAC2/4.6c/298)", which co-finances the Cooperation Program INTERREG V-A Spain-Portugal MAC (Madeira-Azores-Canarias) 2014–2020. IX programa Mecenazgo Alumni-ULL 2022.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. IAVCEI. Available online: https://www.iavceivolcano.org/ (accessed on 22 September 2022).
2. Tanguy, J.; Ribière, C.; Scarth, A.; Tjetjep, W. Victims from volcanic eruptions: A revises database. *Bull. Volcanol.* **1998**, *60*, 137–144. [CrossRef]
3. Dóniz-Páez, F.J.; Hernández, P.; Pérez, N.; Hernández, W.; Márquez, A. TFgeotourism: A project to quantify, highlight, and promote the volcanic geoheritage and geotourism in Tenerife (Canary Islands, Spain). In *Volcanoes—Updates in Volcanology*; Németh, K., Ed.; Intechopen: London, UK, 2021. [CrossRef]
4. Németh, K.; Casadevall, T.; Moufti, M.R.; Martí, J. Volcanic Geoheritage. *Geoheritage* **2017**, *9*, 251–254. [CrossRef]

5. Dóniz-Páez, J.; Beltrán Yanes, E.; Becerra-Ramírez, R.; Pérez, N.; Hernández, P.; Hernández, W. Diversity of volcanic geoheritage in the Canary Islands, Spain. *Geosciences* **2020**, *10*, 390. [CrossRef]
6. Erfurt-Cooper, P.; Cooper, M. *Volcano and Geothermal Tourism. Sustainable Geo-Resources for Leisure and Recreation*; Earthscan: London, UK, 2010; p. 378. [CrossRef]
7. Erfurt-Cooper, P. *Volcanic Tourist Destinations. Geoheritage. Geoparks and Geotourism Series*; Springer and Science Press Ltd.: Berlin/Heidelberg, Germany, 2014; p. 384.
8. Sigurdsson, H.; Lopes, R. Volcanoes and Tourism. In *Encyclopedia of Volcanoes*; Sigurdsson, H., Rymer, H., Stix, J., McNut, S., Eds.; Academic Press: San Diego, CA, USA, 2000; pp. 1283–1299. [CrossRef]
9. Gobierno de Canarias. Available online: https://www.gobiernodecanarias.org/infovolcanlapalma/pevolca/ (accessed on 22 September 2022).
10. Diario La Vanguardia. Available online: https://www.lavanguardia.com/natural/20210322/6603942/turistas-desafian-volcan-erupcion-islandia-recuerda-barbacoa-verano.html (accessed on 22 September 2022).
11. Cable News Network (CNN). Available online: https://cnnespanol.cnn.com/video/erupcion-volcan-kilauea-hawaii-turismo-atraccion-nuestro-mundo-cnne/ (accessed on 22 September 2022).
12. Diario El País. Available online: https://elpais.com/economia/2021-03-30/la-erupcion-de-un-volcan-desata-un-boom-turistico-en-islandia.html (accessed on 22 September 2022).
13. Diario El País. Available online: https://elpais.com/sociedad/2021-10-26/fin-de-semana-en-la-palma-lleno-por-volcan.html (accessed on 22 September 2022).
14. Diario El País. Available online: https://elpais.com/sociedad/2021-11-01/el-turismo-volcanico-desborda-la-palma-en-el-puente-autobuses-llenos-y-atasco-en-la-carretera.html (accessed on 22 September 2022).
15. Kubalíková, L.; Drápela, E.; Kirchner, K.; Bajer, A.; Balková, M.; Kuda, F. Urban geotourism development and geoconservation: Is it possible to find a balance? *Environ. Sci. Policy* **2021**, *121*, 1–10. [CrossRef]
16. Kubalíková, L.; Bajer, A.; Balková, M.; Kirchner, K.; Machar, I. Geodiversity Action Plans as a Tool for Developing Sustainable Tourism and Environmental Education. *Sustainability* **2022**, *14*, 6043. [CrossRef]
17. ISTAC. Available online: http://www.gobiernodecanarias.org/istac/ (accessed on 22 September 2022).
18. GRAFCAN. Available online: https://visor.grafcan.es/visorweb/ (accessed on 22 August 2022).
19. Civico, R.; Ricci, T.; Scarlato, P.; Taddeucci, J.; Andronico, D.; Del Bello, E.; D'Auria, L.; Hernández, P.A.; Pérez, N.M.; Asensio-Ramos, M.; et al. *2021 Cumbre Vieja volcano eruption (La Palma, Spain) SfM DSM, January 2022*; OpenTopography: La Jolla, CA, USA, 2022. [CrossRef]
20. Carracedo, J.C. *Los Volcanes de las Islas Canarias, Vol IV*; Editorial Rueda: Madrid, España, 2008; p. 213.
21. Ferrer-Valero, N.; García-Romero, L.; San Romualdo-Collado, A.; Vegas, J.; Dóniz-Páez, J.; Mangas, J. A sudden beaches formation on the coastal lava-deltas of the 2021 volcanic eruption on La Palma. In Proceedings of the VIII International Symposium on Marine Sciences, Las Palmas de Gran Canaria, Canary Islands, Spain, 6–8 June 2022.
22. Romero, J.E.; Burton, M.; Cáceres, F.; Taddeucci, J.; Civico, R.; Ricci, T.; Perez, N.M. The initial phase of the 2021 Cumbre Vieja ridge eruption (Canary Islands): Products and dynamics controlling edifice growth and collapse. *J. Volcanol. Geotherm. Res.* **2022**, *431*, 107642. [CrossRef]
23. Martí, J.; Becerril, L.; Rodríguez, A. How long-term hazard assessment may help to anticipate volcanic eruptions: The case of La Palma eruption 2021 (Canary Islands). *J. Volcanol. Geotherm. Res.* **2022**, *431*, 107669. [CrossRef]
24. Ferrer, N.; Vegas, J.; Galindo, I.; Lozano, G. A geoheritage valuation to prevent environmental degradation of a new volcanic landscape in the Canary Islands. *Authorea* **2022**, preprint. [CrossRef]
25. González, P. Volcano-tectonic control of Cumbre Vieja. *Science* **2022**, *375*, 1348–1349. [CrossRef] [PubMed]
26. Naturtravel. Available online: https://www.natour.travel/tour-item/ruta-del-nuevo-volcan-cumbre-vieja/ (accessed on 22 September 2022).
27. Poblete, M.; Beato-Bergua, S.; Marino, J.; Herrera, D. Geoturismo con realidad aumentada en la zona volcánica del Campo de Calatrava (Ciudad Real). *Ería* **2022**, *42*, 73–106. [CrossRef]
28. Praticò, S.; Neves, M.; Merlino, A.; Tripodi, R.; Bonomo, P.; Barreira, P.; Modica, G. Virtual Reality Approach for Geoparks Fruition During SARS-CoV2 Pandemic Situation: Methodological Notes and First Results. In *New Metropolitan Perspectives. NMP 2022. Lecture Notes in Networks and Systems, Volume 482*; Calabrò, F., Della Spina, L., Piñeira Mantiñán, M.J., Eds.; Springer: Cham, Switzerland, 2022. [CrossRef]
29. Pasquaré Mariotto, F.; Bonali, F.L. Virtual geosites as innovative tools for geoheritage popularization: A case study from Eastern Iceland. *Geosciences* **2021**, *11*, 149. [CrossRef]
30. Pasquaré Mariotto, F.; Bonali, F.L.; Tibaldi, A.; De Beni, E.; Corti, N.; Russo, E.; Fallati, L.; Cantarero, M.; Neri, M. A New Way to Explore Volcanic Areas: QR-Code-Based Virtual Geotrail at Mt. Etna Volcano, Italy. *Land* **2022**, *11*, 377. [CrossRef]