

Geo-Singularity of the Valley-Fault of Teixidelo and Candidacy to Geopark of Cape Ortegal (NW Iberian Peninsula): Preliminary Assessment of Challenges and Perspectives

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Abstract

Recently, a project has been set in motion to declare the Cape Ortegal complex (NW Iberian Peninsula), a geological reference in Spain and Europe, as a geopark. This initial phase has the purpose of reflecting and discussing the benefits of creating a geopark as a tool to foment education in geodiversity, geotourism, and scientific debate. We define geo-singularities as those elements of a geopark that stand out the most to a tourist due to their processes, forms, compositions, or mere presence in situ, being able to do so in a scientific, spiritual or sensitive manner, among others. Geo-singularities are, therefore, of first-rate geotourism value. This case report focuses on the Teixidelo valley-fault geo-singularity, whose main attraction is the movement of its base (> 30 m in the last 70 years). We relied on field observations and literature review and benefited from discussions during conference workshops, meetings, and personal interviews with local associations, the local community, and municipal administrators. Thanks to this information, we were able to conduct our analysis towards the development of a collective reflection exercise about tourism on a global, regional, and local level, capable of providing insight to politicians and local organizations in the management of geotourism at the Cape Ortegal complex, as well as questioning if the geopark is a good strategy for the member municipalities. This analysis and collective interpretation allowed us to determine the potentialities, dangers, and challenges of the Teixidelo valley-fault as a geotourism asset in the framework of the Cape Ortegal complex. The current tourism situation, within a global context, is characterized by a significant increase in tourists who have experienced different geological assets. In many cases, this translated into a massification of places that were not prepared to receive so many tourists. We have identified two types of massification: projected (places that the Administration promotes without a proper

management and protection plan) and another random one (the popularity of a place for a specific and unforeseeable reason). Geo-singularities are a strategic tool that can become a showcase piece for a geopark. The type of management strategy applied will largely determine the future geo-conservation of the geological values of the study area. Based on this, a first action plan was designed aimed at municipal governments and local associations. The reflections, approaches, and proposals carried out in this case report can be extrapolated to other territories, whether or not they are geoparks.

Keywords

Geopark
Geo-singularity
Geotourism
SWOT analysis
Galicia

Electronic supplementary material

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Introduction

For decades, biodiversity has symbolized the natural value of many territories, being the icon of conservation and leisure (Crofts 2014). Geological and geomorphological values, on the contrary, have been relegated to the background, or simply, do not have the attention that the biological aspects enjoy (Ollero 2017). Currently, several countries have natural heritage laws that consider geological heritage and geodiversity as another form of approaching a territory, its people, customs, and natural values, which have served to recognize, promote, and protect geological property (García-Álvarez 2009; Costa-Casais et al. 2015).

The dialogue that non-local society establishes with the geological territory is channeled through geotourism. The territories that are present in Sites of Geological Interest (SGIs, going forward) or Global Geosites (GGSs), and that often form a geopark (GP), tend to englobe most geotourism. There is no internationally accepted definition of geotourism, although in the last 5 years, the proposal of Newsome and Dowling (2010) has been used quite a bit. These authors define geotourism as nature tourism focused specifically on the geology and landscape, and capable of promoting a knowledge of Earth sciences through

appreciation, enjoyment, and learning. Geotourism must also be associated with sustainable development of the territory, preserving its culture, traditions, and customs, and without interfering with the local way of life (Fernández-Martínez and Castaño de Luis 2011; Hose et al. 2011). GPs constitute the ideal stage for this type of practice because, although they are not protected natural areas or have normative characters, they defend the protection and enhancement of the geological heritage of the territory as a sustainable propeller for economic and social development (Burek 2012).

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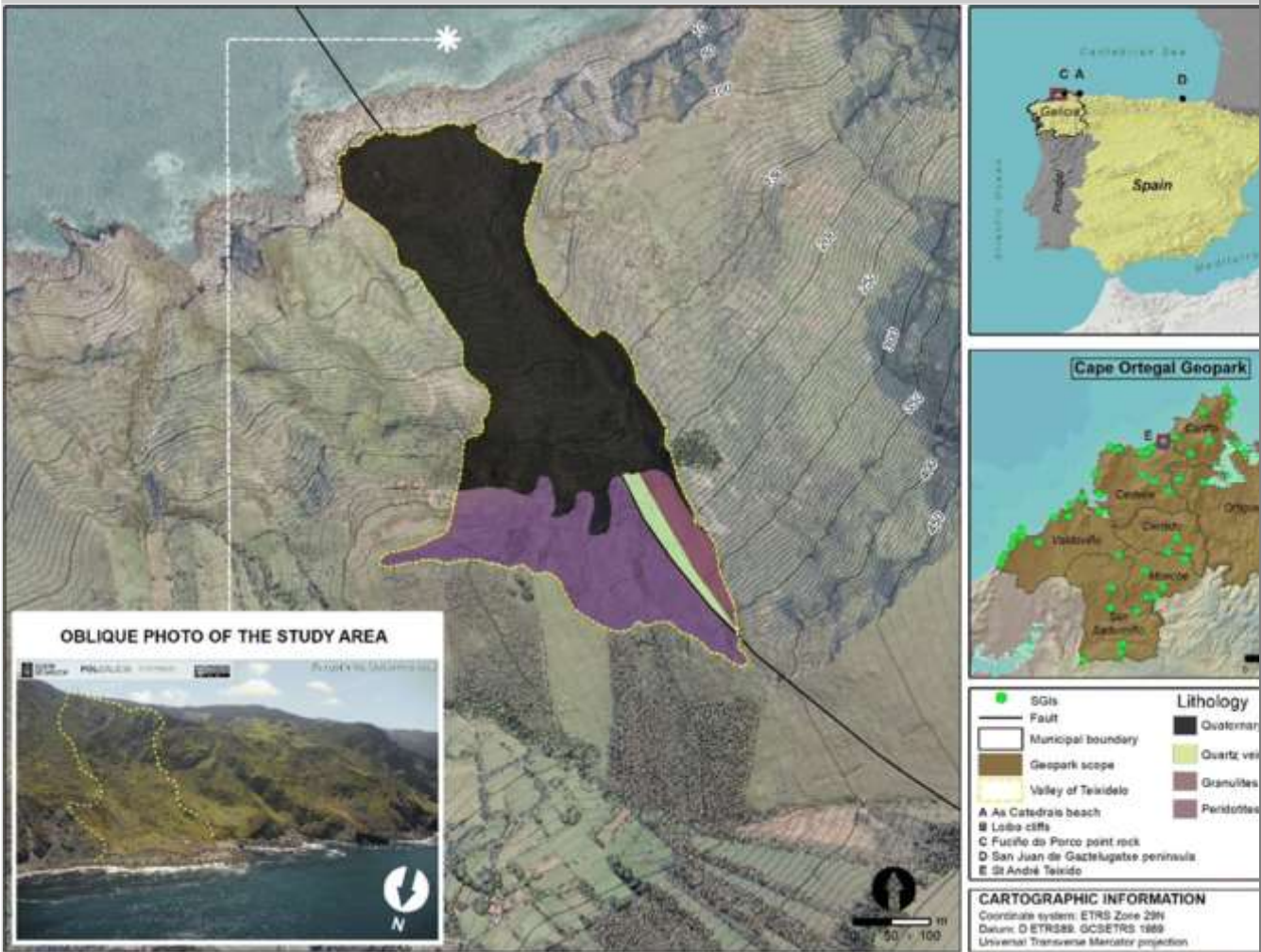
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In this context, in 2014, the Creation of the Cape Ortegal Geopark project was presented to the municipal corporations of eight municipalities in the NW of the Iberian Peninsula (see Fig. 1) (henceforth XPCO; its initials in the native language: Galician) (Canosa 2014). The Cape Ortegal complex is a reference in geology in Spain and Europe. It is credited as such in the publication of numerous research projects or the submission of doctoral theses from the universities of Leiden (Holland), Montpellier (France), or the Spanish universities of Bilbao, Oviedo, Madrid, and Salamanca. Its main attractions, and at the same time tourist potentials, are the presence of some of the best global outcrops (with rocks present at a depth of 70 km or at the bottom of the ocean), one of the highest coastal cliffs in Europe, as well as a marked historical, sports, religious, and mining heritage. The XPCO project is currently in the formative phase. Of the milestones achieved to date, the following stand out: (i) the creation of the association “Friends of the Geological Park of Cape Ortegal,” which has more than 200 members and more than 55,000 visits to its blog since the year 2015; (ii) the presentation of the inventory prior to SGIs in the XI National Congress of Geological Heritage (Canosa 2015); (iii) the nine round tables that in total gathered more than 260 participants; and (iv) the presentation of XPCO in mineral fairs, with the attendance of more than 15,000 people to some fairs. The following steps of the XPCO bifurcate into three parallel proceedings, in line with the requirements that UNESCO requires for the declaration of a GP: (a) the elaboration of the master plan, signage, and other necessary actions for the presentation of the candidacy to GP (the project application has recently been approved by the Heritage Plan of the Provincial Government, earmarking an economic endowment of half a million euros); (b) the creation of the association for the management of the same; and (c) the study of unique geotourism values that foster education in geodiversity, geotourism, and scientific discussion.

Fig. 1

Geologic and topographic map with the location of the Teixidelo valley-fault, within the Cape Ortegal Geopark (XPCO). In the case report, XPCO is used to refer to the area of study, although it is still not officially a geopark. In the initial project, there were eight municipalities, but currently only seven, since the municipality of As Somozas dissociated itself from the project due to lack of support

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The current case report focuses on item (c). For its development, we define the term geo-singularities as those elements of a GP that are most notable for tourists due to their processes, forms, composition, or simple presence in situ, doing so in a scientific, spiritual, or sensitive manner among others. This means that SGIs with less scientific-geological values than others can be considered as a geo-singularity, instead of those of greater scientific relevance (Migoñ and Pijet-Migoñ 2017; Motte and McInnes 2019). The geo-singularities will coincide with an SGI when these are also presented as the most attractive to the tourist. Geo-singularities must be, therefore, of first-rate geotourism value, capable of providing new experiences in GPs and promoting sustainable, innovative, and educational tourism (Julia 2017).

The geo-singularity studied in this work is the geoheritage value of the Teixidelo valley-fault dynamic (henceforth vFT) (Fig. 1). The vFT is considered by expert analysis to be one of the most relevant geological assets of the XPCO (subject to confrontation with tourists), and as a key tool to support the geopark's strategies in conservation and management. This case report is based on field observations and literature review, and it has benefited from discussions during conference workshops, meetings, and personal interviews with local associations, local communities, and municipal administrators. With this information, we were able to conduct our analysis towards the development of a collective reflection exercise about tourism on a global, regional, and local level (vFT-XPCO), capable of providing insight to politicians and local organizations in the management of geotourism of the XPCO, as well as questioning if the GP is a good strategy for the member municipalities. This analysis and collective interpretation allowed us to determine the potentialities, dangers, and challenges of the vFT as a geotourism asset in the framework of XPCO.

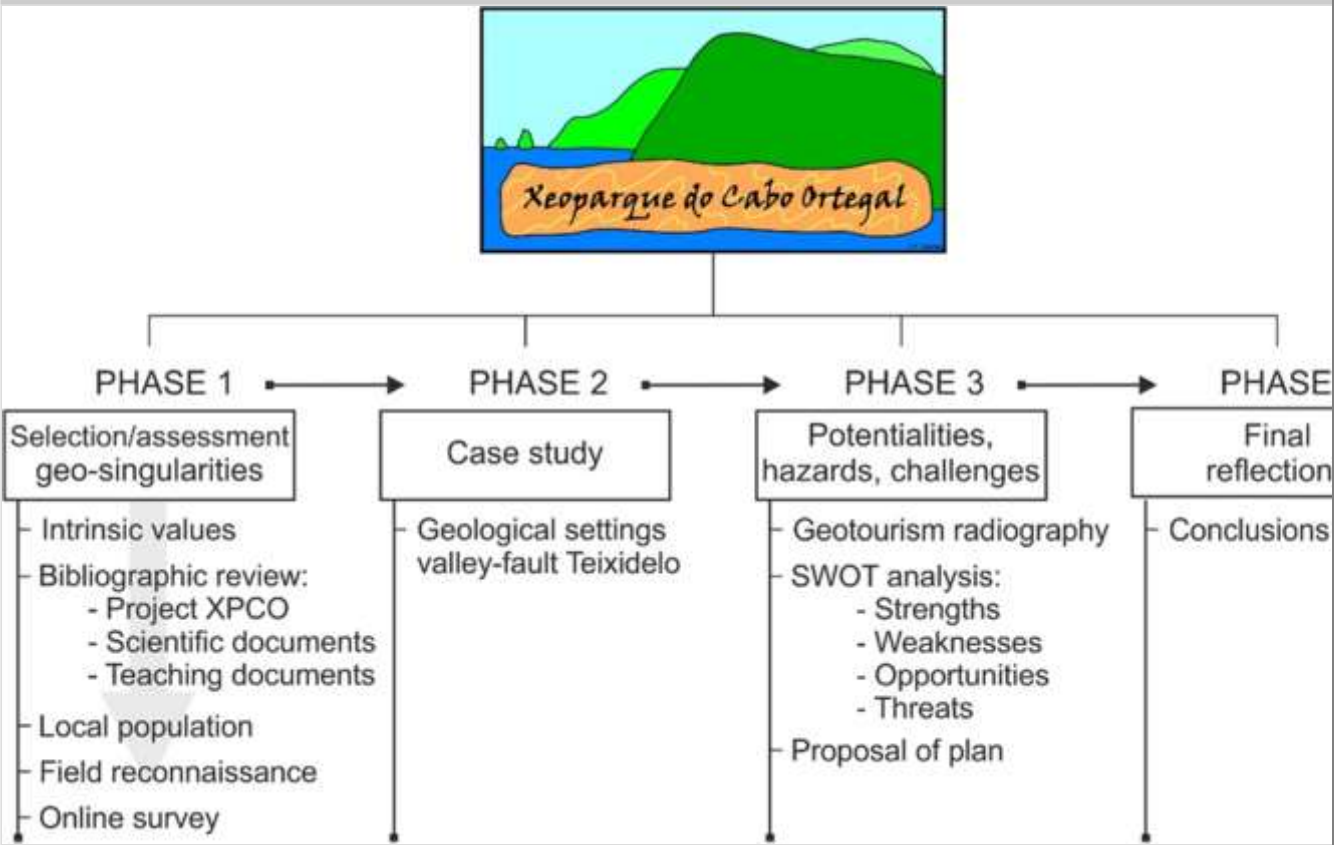
Area of the Study, Geological Setting, and Procedure

The vFT (0.15 km²) is located on the coastal side of A Capelada (Galicia, NW Iberian Peninsula), an area of flat top cliffs exceeding, in most areas, 32° slopes, reaching 88° in certain zones. In its upper part, there are flat surfaces that do not reach 8° in some places and 16° in others. The vFT cuts the cliffs perpendicularly in the vicinity of one of the higher areas (Vixía Herbeira, 612 m). Contact between the valley and the flattened surfaces is produced in the header area, forming a strip of steep escarpments. In the areas closer to the coastline, the valley is wider, and the slopes are smoother (Fig. 1).

The XPCO proposal (~ 630 km²) follows the administrative boundaries, although the criteria used for the delimitation were the origin and geological characteristics of different formations (Duque-Lucas et al. 1983; Martínez-Catalán et al. 2002). The vFT is situated north of the XPCO (municipality of Cedeira), represents 0.02% of its surface, and is home to the Teixidelo Coast SGI (mineralogical, geomorphological, and petrological interest) and Valley of Teixidelo SGI (tectonic, mineralogical, and petrological interest). Most of the area of the XPCO is demographically depressed, with a rapidly aging population. The economy is linked to the primary sector, although great contrasts are visible where industry or tourism sectors are more developed. The population is dispersed, although this characteristic is breaking down due to the mass rural exodus and a greater demographic concentration in towns and villages.

The work method is structured in four sequential steps, but with execution times and its own methodologies (Fig. 2), which combine field and office works.

Fig. 2
Work flow applied to the case report



Phase 1. Selection and Evaluation of Geo-Singularities

Several geologic assets were selected considering the intrinsic values that the XPCO presents (scenic value of the landscape and geological peculiarities). In order to be more concrete about these assets, (i) an exhaustive bibliographical review, (ii) an exchange of opinions with the local population, and (iii) an intensive field analysis of the area of study were carried out. The phase 1 study concluded with the identification of nine potential geo-singularities arranged within the categories of rocks and minerals, cliff landscapes, and geomorphological dynamics (Table 1).

Geo-singularity	Selection				Description
	IntVal	BibRev	LocPop	FieRec	
Rocks & minerals					
Speleothems, copper sulfate and iron ⁽¹⁾	X	X			Formations in old underground mines
Outcrops ⁽²⁾	X	X		X	Location type or exceptional rocky set
Black & red beaches ⁽³⁾				X	Sands with a very unique mineralogical composition
Unique minerals ⁽⁴⁾	X	X			Location type or very striking mineral species: Zaraitze (nickel carbonate)
Landscape cliffs ⁽⁵⁾	X	X	X	X	Some of the highest cliffs of Europe and present in Red Natura 2000

Geomorphologic dynamic			
Ecogeomorphology ⁽⁶⁾	X	X	Interactions between organisms and the development of landforms
Teixidelo Valley-fault ⁽⁷⁾		X	Sliding at the base of the Valley, noting a movement of more than 30 m in 60 years
Landslides ⁽⁶⁾		X	Very active geomorphologic dynamic, with abundant annual evidence
River drain ⁽⁶⁾		X	Fluvial sinkhole with ~250 m of travel

able 1

election of potential geo-singularities and reasons for selection

Where: IntVal (intrinsic values), BibRev (bibliographic revisions), LocPop (local population), FieRec (field reconnaissance)

In the process of the bibliographical review, the *Creation Project of the Cape Ortegal Geopark* played a large role (Canosa 2014). This document contains the inventory of 40 SGIs, considering as selection criteria the intrinsic value, the potentiality of use, and the need for protection. Currently, there are 15 other SGIs listed (Fig. 1). Eight SGIs are integrated in some of the GGSs of the XPCO. A complete review of scientific studies on the XPCO was also made. To date, several dissertations, articles, and scientific books have been published (Arenas 1988; Monterrubio et al. 1992; Azcárraga 2000; Mendía 2000; Marcos et al. 2002; Puelles 2004; Verde-Vilanova 2009), as well as descriptive and didactic material of a different type (Lahuerta-Mouriño and Lucas-Domínguez 1990; Ábalos et al. 2000; Martínez-Catalán et al. 2013; Arán-Ferreiro et al. 2014; Canosa 2015). The memoirs of the geological maps made in recent decades by the Geological and Mining Institute of Spain provided complementary technical information of interest.

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In the exchange of views with the local population, 93 interviews were conducted with a single open question: “What natural asset in your area do you most like or appreciate?” 80.7% of the respondents pointed out the landscape of XPCO as the most striking natural asset, with special emphasis on the cliffs, beaches, and sea. The rest of the responses focused on: landscape in general (8.8%), native forest (8.8%), and the geology (without any major specification) (1.8%). Being an open question, most of the answers were also open, contrary to our intention when conducting the survey. Thus, in a single response, several parts of the XPCO were included, making it difficult to discriminate a particular natural asset.

The study of the terrain was developed according to expert criteria, but after consulting technicians (geographers, geologists, topographers, agronomists, among others) who work or worked in the area of study. The terrain treks were made following the 10 georoutes developed to date in the XPCO (see Canosa 2015 and rutasgeologicasdeg Galicia.blogspot.com.es). The trips were carried out in six field seasons between 2014 and 2015.

The assessment of selected assets was made by means of an online survey of more than 500 visitors to the XPCO during the year 2016 (Fig. 3). The survey was implemented through Google Forms. Tourists that visited the XPCO through the georoutes were asked to rank the three most relevant assets of the nine types that were selected (Table 1). The survey was answered by 120 tourists (22.9%), of which 45.8% consider the vT and black and red beaches as the most impressive elements (both sites are in the same place). It was followed by the cliff landscapes (23.8%) and the ecogeomorphological dynamic (11.9%). Information on the age, sex, occupation, level of studies, and place of residence of each interviewee was also collected. The social mass interviewed was split equally between men and women (~ 50%), with dominant age ranges between 35 and 50 (37.7%), 50 and 65 (34.9%), and 18 and 35 (21.7%). Eighty-three percent have higher education and 16.0% secondary education. 36.2% of the visitors were from the municipalities that make up the XPCO, 41.1% from the region of Galicia, and 22.7% from the rest of Spain. Due to the lack of data on tourists, a selection process of the visitors was not carried out. The online interview was sent to all those tourists who met the requirement to have knowledge of all nine geo-singularities selected (Table 1).

Fig. 3

Georoute carried out during August 2016 in Cape Ortegal Geopark

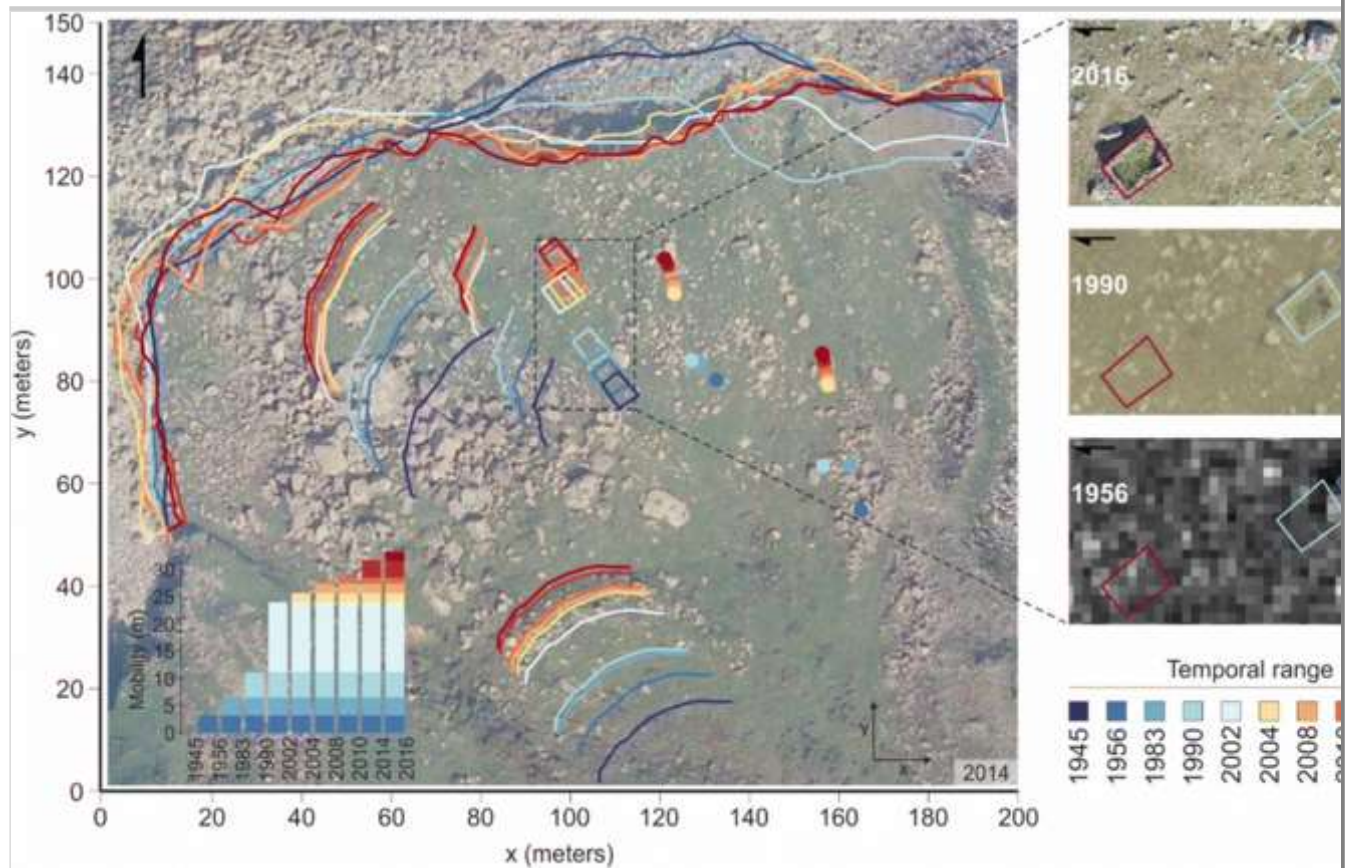


Phase 2. Case Study: Teixidelo Valley-Fault

We can really say that vft black and red beaches and landscape cliffs would equally appear to be the most appreciated natural assets. The selection of the vft as a possible geo-singularity adhered to two reasons. First, because it forms part of two SGIs (see the “Area of study and geological settings” section). Second, due to the need to establish an adequate management plan for a geoecologically sensitive sector (valley), especially since the recent discovery that the base of the valley has moved ~ 30 m in the last 70 years. This discovery is increasing the arrival of tourists to the area due to the diffusion that “the earth moves” at a rate of half a meter per year. The evidence of the movement was discovered by the work team while comparing aerial photos from the years of 1956 and 2014 and detecting the movement of an old mining construction (Fig. 4).

Fig. 4

Photo-interpretive analysis of the 10 periods that were studied by Horacio et al. (2016), where: point vectors represent blocks, line vectors represent lobes and coastline scarp, and polygon vectors represent the old mining construction. The SW corner of the mining construction was used as a reference to determine the displacement of the valley (mobility chart)



Horacio et al. (2016) related the rate of movement of the valley between 1945 and 2016 (and seven intermediate periods) with the number and intensity of sea storms and episodes of heavy rainfall. The general direction of movement is NW, but with a highly variable spatial mobility between each period. Between 1945 and 2016, it moved by 33.4 m (0.44 m/year) and 30.2 m between 1956 (had better image quality than 1945) and 2016 (0.50 m/year). This movement represents the intrinsic value of v_{fT}. The tourist value derives from the assessment made by tourists of the places visited.

Horacio et al. (2016) point out the intrinsic characteristics that surround the environment of v_{fT} as explanatory of the process. This environment is defined by its structural context (lithology + tectonics), which in combination with the weather conditions, present and past, have been setting up a kind of relief, with its own topography and processes. The clay base (plastic behavior) and the slopes with gradients > 35% of the v_{fT} are considered the most relevant parameters of the intrinsic characteristics. A triangle with three types of explanatory factors of the v_{fT} movement is drawn on these basic conditions: (i) conditioning factor (sea storms), responsible for eroding the coastline through waves and generating instability through distension (removal of weight at the base of the valley); (ii) trigger factor (episodes of heavy rains), responsible for activating the movement through the hydration of the clay; (iii) external factors

(linked to human activity), with the ability to modify the natural dynamic of the system, possibly directly affecting the conditioning and/or trigger factor.

Phases 3 and 4. Potentialities, Dangers, and Geotourism Challenges of vfT-XPCO

The last two phases are initiated with an analysis and interdisciplinary reflection on geodiversity and geotourism. In the exercise, different points of view derived from the composition of the team (specialists related to the natural sciences, social, and of the local administrative area) are collected. Finally, it places the focus on the management of the vfT so that it can contribute to balanced geotourism that fosters the value of geodiversity. The contribution of the local associations, local communities, and municipal administrators were fundamental for these phases. Ideas were exchanged with these groups through workshops, conversations, and interviews. We developed two types of event for information exchange, namely “events for the general public” and “events for the Administration.” Regarding the first, we carried out 10 information talks, eight over the municipalities interested in the GP candidacy, one in the Natural History Museum of Ferrol, and the last one at the Annual Mineral Fair of Santiago de Compostela. The workflow during the events followed two steps, each one divided into several subsections: (i) general presentation of the project (i.1. what is a GP; i.2. how does it work?; i.3. benefits for the territory; i.4. implications; i.5. obligations; i.6. limitations). (ii) The project of XPCO itself (ii.1. geological asset highlights of each municipality; ii.2. other highlights that contribute to a stronger candidature of XPCO as a GP and its uniqueness as a GP). The points of importance for the public are synthesized in the following four issues: a. urban and rural land use limitations; b. the GP mark as a sign of quality; c. compatibility between industrial activity and heritage conservation; d. positive and negative aspects of the GPs in other sites. The contributors were profiled as people who live in the affected area, local employers, local associations, and local communities. There was a small presence of people without any link to the site.

The events securing information exchange for the Administration were held in nine municipalities and another with technicians from the provincial Administration in A Coruña, the organization which recently approved the budget for the candidacy for the GP project. The workflow during the events followed three steps. The first two are the same as the events for the general public; the third was a debate about the support for the project and the potential problems resulting from project approval by UNESCO. The points of importance for the technicians are synthesized in the following six issues: a. management model and administration of the GP; b. annual maintenance cost; c. urban and

rural land use limitations; d. protection, conservation, and a defined value of the heritage; e. benefits and problems; f. the degree of contribution to the GP by the local economy. The contributors were profiled as legal representatives of the municipalities involved in the project and participating political parties. Also, local municipal and tourist development technicians made a contribution.

X-ray of Geotourism: from the Global to the Local

The UNESCO Global Geoparks Program encourages an improved awareness of geodiversity in society and promotes practices of protection, education, and tourism. This changing trend towards a more geo-aware society is visible in the remarkable growth that the different terms have experienced in recent years that encompass the “geo” field (Benito-Calvo et al. 2009; ~~Newsome and Dowling~~ and Newsome 2010; Hose 2016), promoting geodiversity as a first-rate natural value (Serrano Cañadas and Ruiz Flaño 2007; Gray 2008; Crofts 2014). This has meant, on the one hand, that the number of GGSs in the world has increased in the last decade (Ruban 2016) and, on the other hand, the growth of interesting initiatives committed to the joint assessment and conservation of biotic and abiotic components of a territory (Musila et al. 2005; Hjort et al. 2012; Świerkosz et al. 2017). Geotourism has continued to prosper at the same time as its growth as a new model of tourism based on geoconservation, ecological sustainability, and territorial development (Henriques et al. 2011; Hose et al. 2011). However, this boom may come more from the academic and local fields, as promoters of their geological heritage, rather than from society, whose knowledge about geotourism remains poor. Even from people with an academic background related to geotourism (e.g., geographers), there are studies that show gaps in the knowledge about what a geopark is (Wójtowicz 2011; cited in Zgłobicki and Baran-Zgłobicka 2013).

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It is also important to point out that, along general lines, the tourists who visit places with an important geological heritage do so more for the scenic value of its landscapes than for the geological value of the element visited (Chen et al. 2015; Mikhailenko et al. 2017). The statistics from the centers of reception and interpretation in Spain indicate that one of the most visited places is Teide National Park (> 4M in 2016), with the volcanic relief as the main attraction and, ahead of that, or close behind, one of the most renowned centers of historical-artistic heritage: the Sagrada Familia in Barcelona (> 4.5M in 2016), the Prado Museum in Madrid (> 3M in 2016), or the Alhambra in Granada (~ 2.5M in 2015). This leads to reason that there are millions of tourists visiting geological heritage sites of great importance that do not do it for the intrinsic value it has, but for its esthetic manifestation.

The highly significant geological value of the territory should be thought of as a motor of first-rate territorial development, especially for socially and economically depressed rural areas (Pulido-Fernández et al. 2011) (e.g., XPCO) or environmentally vulnerable locations (Ólafsdóttir and Dowling 2014). However, geotourism is a kind of tourism and as such, sometimes presents a dual behavior which places it in a constant focus of debate: core economic-labor wealth or dynamization of towns and rural areas vs ecological degradation, massification of tourists, neighborhood unrest. The opportunities that (geo)tourism offers for some can be viewed as threats for others. The use of geo-singularities as a tourism attraction (Farsani et al. 2014; Jorgenson and Nickerson 2016; Cocean and Cocean 2017) must be done, therefore taking into account the dual condition that (geo)tourism can present. The so-called effect of a geo-singularity should help to meet the objectives of a GP (environmental education + geotourism + scientific discussion), and not to become a risk for the geological heritage that it represents or for the life of the local population.

The Galician coast has experienced a significant increase in the last years of the number of visitors due to the great scenic value of its geological landscape. This new stage has derived in mass tourism in places that were not prepared to receive so many tourists, being forced, in many cases, to activate quick management plans. This process could be divided into what we define as projected massification and random massification. The first type refers to those places where the Administration strengthened tourism. The clearest example occurs in As Catedrais beach (Fig. 5a). The massive increase of tourists in recent years resulted in a failed experiment on the part of the Administration, projecting As Catedrais beach to the world without an adequate management and protection plan. The direct consequences are that this natural space of great geological value (declared as Site of Community Importance, Natural Monument, and member of the Natura 2000) has been overwhelmed by the number of tourists (at present, it is necessary to request entry for your visit; however, the number of entries allowed per day is still very high). The volume of vehicles and people walking over the cliffs is also causing serious problems of erosion, in many cases, with irreversible damage to the ecosystem. On March 31, 2018, a tourist died from a cranioencephalic trauma due to the collapse of a stone (first fatal victim in As Catedrais beach). The cliffs in periods of rainfall have a hydrostatic overload on the rocks and that causes mass movements. This, added to the constant erosion caused by the tourists that access the beach, has unleashed the problem. It is paradoxical that despite state protection policies for the beach, conservation in the last 10 years has worsened at an alarming rate. The protection policies were possibly well-formulated in their beginning stage but were poorly executed by local governments as they were understood as an

opportunity to offer an asset that was well-supported by a distinctive quality that would attract potential (geo)tourists.

Fig. 5

Different scenarios in which tourism presents massification problems. (A) As Catedrais Beach (© La Voz de Galicia). (B) “Overbooking” in viewpoint from the Bank of Loiba (© Casa Rural a Pasada). (C) Rocky outcropping in Fuciño do Porco (© La Voz de Galicia). (D) San Juan de Gaztelugatxe peninsula (© Fernando Domingo-Aldama). See Fig. 1 for the location of the places



The other process of massification, of a random type, has a certain haphazard component that makes it unpredictable. In Galicia, two places could symbolize this phenomenon: (a) the Bank of Loiba (belonging to the XPCO) (Fig. 5b), where tourism was massified within months due to a prize-winning photo of the place by The World at Night (TWAN). (b) Rocky outcropping of Fuciño do Porco (Fig. 5c), which quickly gained popularity thanks to a press release announcing the opening of a footbridge to improve access to a maritime beacon. This type of tourism is difficult to manage because it is impossible to know where, when, and how it is going to happen. Outside of Galicia, there was also a recent massive boom of tourists on the peninsula of San Juan de Gaztelugatxe (Euskadi) (Fig. 5d) due to the filming of scenes from the series Game of Thrones.

The concentration of such a large number of tourists in a short period of space and time results in serious environmental problems for the geoheritage site, for the local population and for other tourists. Additionally, it often results in the arrival of tourists with more zeal for collecting visited places than of tourists with a true geo-conscience (prototype of the ideal tourist), who escape in search of less crowded places. Protectionism can be a solution or a necessity, but it should not be the finality? Why protect a space if you do not know how to relay to people the importance of preservation and coexistence? Protection through a legal framework, but without a society that is aware and informed, is not a valid tool.

Potentialities, Dangers, and Challenges of the Teixidelo Valley-Fault

The number of tourists that currently visit the XPCO is relatively low, although the trend of recent years points to a significant increase. This situation must also be analyzed within the context of the phenomenon of global tourism and the “viralization” made by media and social network sites. The cases of random overcrowding described (Fig. 6 images 2–4) advised caution with the geotourism management planned for the vFT. Its condition as a geo-singularity places it as one of the sites with the greatest potential number of visits and perhaps as one of the elements of reference of the XPCO in the next few years. It must also be taken into account that (i) the vFT is or may be a transit point for other sites (e.g., see Table 1) black and red beaches, ecogeomorphological dynamic, landslides, river drain), and (ii) the concentration of tourists in a geomorphological area so dynamic and sensitive to erosion can cause accidents, especially due to the absence of signs and studies that report on risk levels.

Fig. 6

Management strategy proposed for the Teixidelo valley-fault. Image 1: technological possibilities applicable in the area of study (see also Santos et al. 2018); image 2: displacement of the downhill trail to the Teixidelo valley-fault between 1990 and 2014; image 3: remains of the Bonnie Carrier ship, which was shipwrecked in the 1990s; image 4: contribution of information to the website through the experience of the geotourists and scientific studies. See also electronic supplementary material

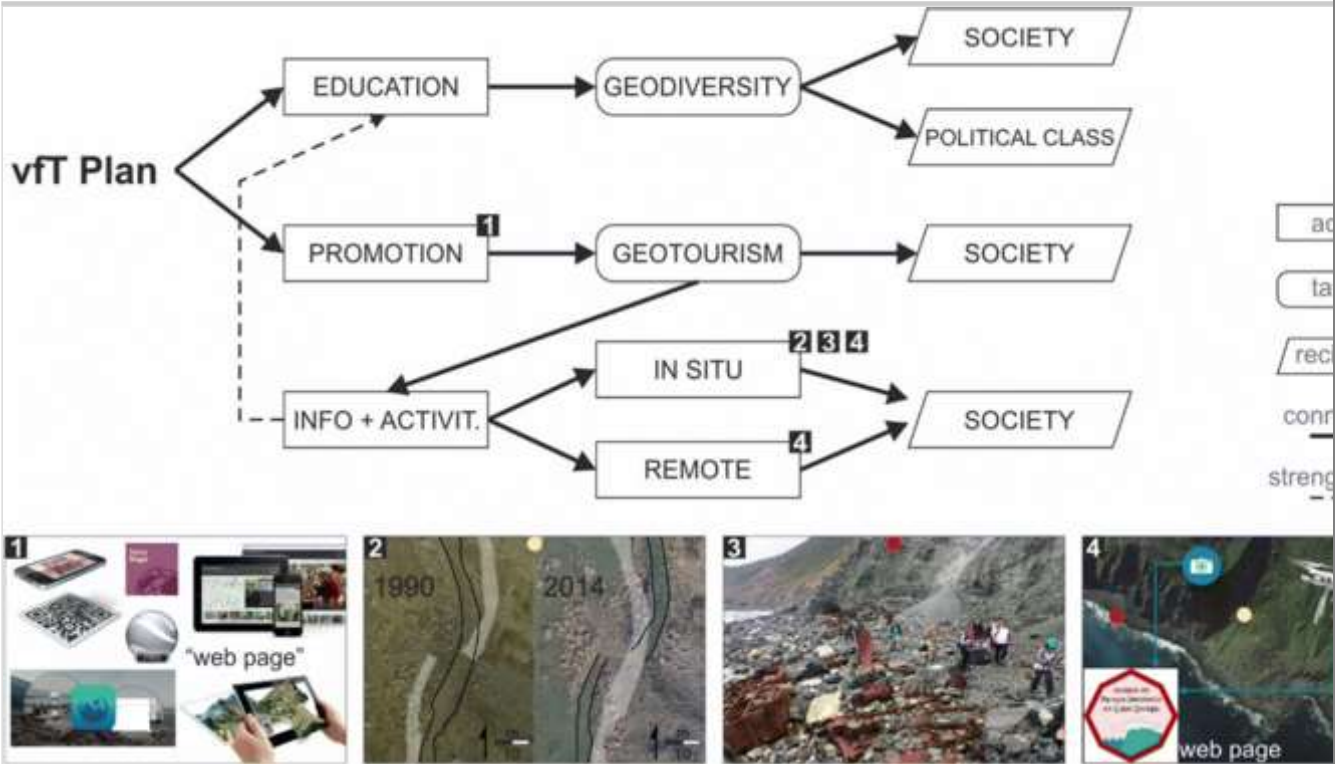


Table 2 includes a SWOT analysis for the vfT and its context. The vfT presents the strength of its own geological/geomorphological value as a geotourism attraction. The lack of infrastructure and services is considered a threat, although it helps for conservation and for dissuading large crowds of tourists. A good policy should preserve this condition of the vfT. Other studies consider the proximity of tourism infrastructure as a strength (e.g., Kubalíková and Kirchner 2016). We think, however, that in this initial stage of discussion about the need or not of a GP for the study area, it is preferable to preserve the anonymity of the place and “gain time” to well define the management measures to be implemented. In the As Catedrais beach (Fig. 5a) advertisements on the highway and the construction of car parks, a restaurant and gift shops favored the concentration of people and the problems mentioned (see “X-ray of Geotourism: from the Global to the Local” section). It is important that the tourist that visits the vfT-XPCO does it because they know about its geological value. If there are infrastructures that favor the visit, it will be a positive point for many tourists who would not have gone if those services did not exist. The municipal capitals have suitable infrastructure to provide services to the tourist. At the vfT, there are three places with services: Santo André de Teixido (basic services) at 2.5 km, Cedeira at 11 km, and Cariño at 13 km. Santo André de Teixido (see Fig. 1) is a religious destination located in the XPCO that attracts a large number of tourists. There are no studies of how many of tourists who visit Santo André de Teixido also visit the XPCO, although it is known that the greatest number of visitors are elderly people traveling on organized excursions who, in general, are not aware of the presence of the XPCO. Some tour packages are beginning to include the

XPCO as a complement to the religious excursion, this being an aspect to consider in the future. Santo André de Teixido is a strong point if management is adequate, but also a threat if it is not handled correctly.

Table 2

SWOT analysis of the Teixidelo valley-fault and its context

Strengths (internal, helpful)
- Element of geomorphological reference, receiver of visitors, and dissemination of the characteristics through the tourist diaspora
- Difficult access to many points of interest, thereby regulates the number of tourists and preserves the landscape better.
- Proximity to the religious enclave of Santo André de Teixido as a tourist attraction
- Rich historic, gastronomic, athletic, religious, and mining heritage in the XPCO
Weaknesses (internal, harmful)
- Poor knowledge about the tourist value of the geological and geomorphological heritage (Zgłobicki and Baran-Zgłobicka 2013)
- Limited knowledge on needs of geotourists (Reynard 2008; Hose 2016) AQ9
- Low desire to discover the assets of inanimate nature (Zgłobicki and Baran-Zgłobicka 2013)
- Absence of regulation of visits to the areas of greater risk of accident and erosion
Opportunities (external, helpful)
- Improvement of scientific knowledge on an SGI
- Contribution of new geological and geomorphological knowledge to society
- Geotourism potential for the XPCO and its candidacy to GP
- Instrument for territorial development (local governments) and promotion (local tourism agencies)
- Possibility of applying diverse strategies to promote and protect (geotourist routes, viewpoints, didactic park) (Walliss and Kok 2014; Kubalíková and Kirchner 2016; Višnić et al. 2016; Migoń and Pijet-Migoń 2017) and geo-educate
- Very suitable for the implementation of cutting-edge technology (Google Earth, QR codes, videos, geoapps, and video games for smartphones and tablets) (Martínez-Graña et al. 2013, 2017)
- Open to the use of Internet as the main source of geotourism information
Threats (external, harmful)
- Absence of tourist infrastructures in the vfT-XPCO surroundings
- Low preparation of the geotourists for the visit (Hose 2016) AQ10

- Political and economic incoherence
- Geological vandalism (see Fig. 7)
- Occurrence of accidents due to the absence of studies on the risk of the area and adequate signage
- Globalization and its consequences (uncontrolled growth that tourism has gained thanks to this phenomenon)
- Economic lobbies

In light of the strengths of the vfT, the weaknesses arising from the low value that society has of geodiversity should be counterbalanced. In order to improve this understanding, the following is needed: (i) scientific studies which delve deeper into the topic of SGIs (Zgłobicki and Baran-Zgłobicka 2013); (ii) educating children about the value of geodiversity; (iii) re-educating the adult population that still has an idea about anything “eco” based solely on the biotic component of a landscape. Good management must be achieved in order to reverse this trend, so that the tourist that only values the scenic impact initially, eventually adds a scientific-geological value to his scale of values. If the geo-tourist is well-informed about what is going to be visited, it will enhance the experience and the geo-tourist will be a good spokesperson for the importance of geodiversity in general, and of the vfT-XPCO in particular.

Educated geotourists are less vulnerable to the threats that the vfT-XPCO may suffer and constitute a social tool of pressure against poor social or political practices. This is more important nowadays because tourism lives within a sort of bubble whose financial assets are the places of interest. As there is supply and demand, tourism is a market ruled by the capitalist dogma. The way of using tourism, and doing so in a very deregulated global market, leads to bad practices. This situation makes it difficult to find solutions that satisfy everyone. The administrations look to obtain economic benefits, while the tourist (consumer) wants to visit (sometimes collect) destinations. If there are no plans for good practices and certain regulation, it is possible that the vfT-XPCO will end up succumbing to tourist massification.

Sheltered from the poles of tourist attraction, emerge economic lobbies. In many cases, they are responsible for the processes of tourist crowds. These practices go against geotourism because they modify traditional lifestyles and orient the local population towards an economic activity focused exclusively on tourism. It is necessary to regulate lobbies. It is a complex task, but they can be stopped, although the political classes are not used to it because, on numerous occasions, they have a direct connection with the lobby. One measure is to provide funds for good practices and not for doing bad practices, in other words, compensate

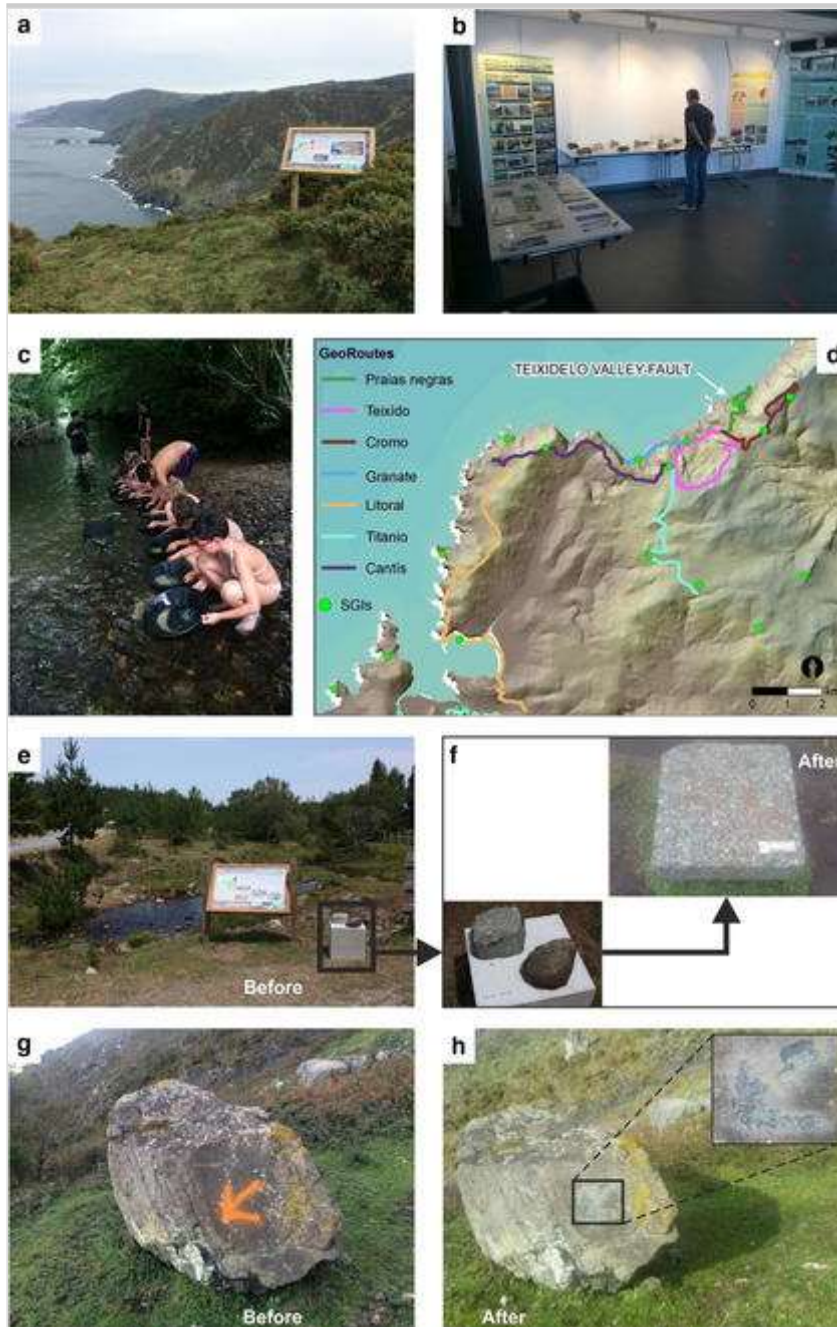
the proactive activities instead of paying for “proactivating.” Political coherence of local, regional, and state governments plays an important role although sometimes this consistency is subject to elections.

The analysis developed on the geo-singularity of the vfT and the situation of geotourism on a global and regional levels has served to reflect potentialities and hazards (Table 2). Figure 6 develops a management plan for the vfT-XPCO that marks the first master lines of action and helps strengthen its candidacy to GP. This strategy is directed towards municipal governments and local associations in charge of management. The plan contemplates two great challenges: (i) improving the evaluation of geodiversity through promoting geological education in society and (ii) promoting geotourism as a type of sustainable tourism with the environment and with the culture and traditions of the territory. The evaluation of geodiversity should focus on society and on political classes, which have the key to effect changes in the territory. The investment of public money in geological assets has to consider that most geological materials are not renewable at human scale; therefore, they must assume the social responsibility of guaranteeing the conservation of their geo-patrimony (Brilha 2016).

To promote geotourism, a combination of in situ and remote activities is proposed, also helping to strengthen education on geodiversity (Figs. 6 and 7). The development of both objectives (geodiversity and geotourism) has to work with the three values of interest of the vfT (scenic, environmental, and scientific). The scenic and environmental values are open to the public. The scientific value is associated with a more select group of geotourists. On the one hand, there are the people who are concerned about science (motivation to learn), and on the other hand, the scientists.

Fig. 7

Examples of divulgation of the geological value of the XPCO (from A to D). The E and F and G and H images collect examples of geological vandalism



The final challenge of the vT plan is not attracting the largest number of geotourists, but to take advantage of its acclamatory effect to generate balanced and educational geotourism. The discovery of the movement of the valley has meant, in effect, a revolution in the XPCO tourists who are striving to visit “the place where the earth moves.” The first consequences are beginning to be felt through the polarization of the local community. The first group is committed to the maximum publicity of the place, while another group wishes to preserve its anonymity and only to be visited by that tourist who has been documented and has a real interest. The acts of geological vandalism also begin to appear (Fig. 7), in some cases associated with the game of advertising vs no publicity of the place and, in others, the limited awareness and culture of some elements of society.

It is important to make sure that the geotourists arriving to the vfT know what they are going to visit and what other alternatives exist within the XPCO. The plan has to contemplate the distribution of the rest of the XPCO for the geotourists attracted to the vfT. This relocation must be supported by (i) the geological interest of other SGIs (Fig. 7d) and (ii) the marked historical, athletic, religious, and mining heritage of the XPCO. In this manner it helps to achieve the objective of promoting the socioeconomic and cultural development at a local level that is required for the creation and operation of a GP. To put these actions into motion, it is vital that the XPCO website complies with the triple function of informing, educating, and promoting. This should be supported by the administrations so that it is considered as the source of official and reliable information of the XPCO. We also believe that the vfT needs its own terrestrial georoute (self-guided) and another maritime route (guided) that follows part of the coastline of the XPCO (see electronic supplementary material).

Conclusions

1. To conclude, we can say that the XPCO project initiative is a good strategy for the members of the municipalities. The movement of people and use of tourism resources is an unstoppable phenomenon at present. We consider that the publicity provided by a GP as a tourist attraction in the territory is a minor threat compared to the absence of regulation and control of tourism. The XPCO project requires, however, the greater involvement of a society unaccustomed to tourism. It is important to understand from the academic world that our study objectives and proposals, although good in intention, do not have to be the most appropriate or, simply, there does not have to be a need to apply them to a territory. Preliminary studies like this serve to check the pulse of society and draw the guidelines before beginning a process of application to GP.
2. The detailed study of SGIs considered as geo-singularities (e.g., vfT) strengthens the intrinsic value of a GP and brings innovative and differential factors to the promotion of geotourism and geodiversity. Promoting education rather than encouraging geomarketing also requires political and economic consistency and that infrastructures that can be designed in the future will preserve the uniqueness and identity of the territory, without putting the interest of tourists ahead of the local population. In various places in Galicia with geological interest, quick plans of tourism management were applied as a reactive measure against the “problem” of tourism, there also being a close relationship between

these plans and the economic and urban development model. The solution would have been to have opted for preventive plans.

3. Geo-singularities are a strategic tool that can become a showcase and representative of a GP. In this way, the vfT should help mediate among the three realities that surround the XPCO in terms of its distinction as a GP: (i) the idiosyncrasy of the Galician society characterized by a strong attachment to property. This generates a certain skepticism towards “parks,” which are conceived as protection policies that govern the territory. There also exists a great misunderstanding about the purpose of a GP. (ii) The support of local governments is fundamental to achieving the distinction of GP. The level of support of the municipalities integrated in the XPCO is very different. In some cases, the number of votes in the next elections may have an underlying impact. (iii) The process of globalization in which we currently live is unstoppable and it has consequences. It is necessary to educate society, especially the locals because they are the real managers and guardians of the good practices carried out in the territory. It is a slow process, but it will serve to generate awareness about the value of geoheritage and its protection.
4. The management plan proposed to municipal governments and local associations exposes the fundamental aspects for the first strategy for global action. The consideration of “blessing” or “curse” that a geological asset can adopt depending on the type and model of tourism that it attracts is closely related with the management strategies that are settled on in the initial stages of the candidacy for a GP. The second stage of the process should materialize into concrete actions.
5. Parallel to the actions carried out from the XPCO local agencies, the work team projects three lines of action within the vfT-XPCO for the next few years: (i) the initiated geomorphological studies will have a permanent follow-up of the vfT movement. The results will be updated on the XPCO website for follow-up by visitors and thus establish a permanent communication between science and geotourists. (ii) Geotourism is a form of tourism as well as an industrial or business activity. This activity requires market studies in the future to collect information about the vfT-XPCO visitor (e.g., income, origin, and level of education). Information about the characteristics of the tourists will allow making proposals of use based on studies of preference. (iii) To apply Brilha’s approach (Brilha 2016) to achieve a numerical evaluation of the value and degradation risk to the geosites of the XPCO.

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Electronic Supplementary Material

ESM 1

(BAK 52 kb)

References

AQ11

Ábalos B, Azcárraga J, Gil Ibarguchi JI, Mendia M & Puelles P (2000) Mapa geológico del Complejo de Cabo Ortegal (NO de España)

Andavira Editorial (1988) Evolución petrológica y geoquímica de la unidad alóctona inferior del complejo metamórfico básico-ultrabásico de Cabo Ortegal (Unidad de Moeche) y del Silúrico parautoctono, Cadena Hercínica Ibérica (NW de España). Corpus Geologicum Gallaeciae

Appreciating physical landscapes: three hundred years of geotourism (2016) Geological Society

Arán-Ferreiro D, Macías F, de Anta RC, Pérez-Alberti A, Otero XL, Verde-Vilanova JR, Pérez-Llaguno C, Saiz-Rubio R, Díez E, Bolaños-Guerrón D & Macías-García F (2014) Complejo Básico-Ultrabásico de Capelada-Cabo Ortegal. Andavira Editorial

Avances y retos en la conservación del Patrimonio Geológico en España. Actas de la IX Reunión Nacional de la Comisión de Patrimonio Geológico (Sociedad Geológica de España), (2011)

- Azcárraga J (2000) Evolución tectónica y metamórfica de los mantos inferiores de grado alto y alta presión del complejo de Cabo Ortegal. *Nova Terra*
- Benito-Calvo A, Pérez-González A, Magri O, Meza P (2009) Assessing regional geodiversity: the Iberian Peninsula. *Earth Surf Process Landf* 34:1433–1445
- Brilha J (2016) Inventory and quantitative assessment of geosites and geodiversity sites: a review. *Geoheritage* 4:45–63
- Canosa F (2014) Proyecto de creación del “Xeoparque do Cabo Ortegal” (Geoparque del Cabo Ortegal)
- Canosa F (2015) Guía geológica de siete georutas en el Concello de Cedeira. Concello de Cedeira
- Chen A, Lu Y, Ng YCY (2015) In: role of tourism earth-science in tourism development. Springer, Berlin Heidelberg
- Coccean G, Coccean P (2017) An assessment of gorges for purposes of identifying geomorphosites of geotourism value in the Apuseni Mountains (Romania). *Geoheritage* 9:71–81
- Costa-Casais M, Caetano-Alves MI, Blanco-Chao R (2015) Assessment and management of the geomorphological heritage of Monte Pindo (NW Spain): a landscape as a symbol of identity. *Sustainability* 7:7049–7085
- Crofts R (2014) Promoting geodiversity: learning lessons from biodiversity. *Proc Geol Assoc* 125:263–266
- Duque-Lucas LC, Elizaga-Muñoz E & Vidal-Romaní JR (1983) Instituto Geológico y Minero de España
- Farsani NT, Coelho COA, Costa CMM, Amrikazemi A (2014) Geo-knowledge management and geoconservation via geoparks and geotourism. *Geoheritage* 6:185–192
- García-Álvarez J (2009) Lugares, paisajes y políticas de memoria: una lectura geográfica. *Boletín de la Asociación de Geógrafos Españoles*:175–202
- Global Geotourism Perspectives (2010) Goodfellow Publishers

Gray M (2008) Geodiversity: developing the paradigm. *Proc Geol Assoc* 119:287–298

Henriques MH, dos Reis RP, Brilha J, Mota T (2011) Geoconservation as an emerging geoscience. *Geoheritage* 3:117–128

Hjort J, Heikkinen RK, Luoto M (2012) Inclusion of explicit measures of geodiversity improve biodiversity models in a boreal landscape. *Biodivers Conserv* 21:3487–3506

Horacio J, Muñoz-Narciso E, Sierra-Pernas JM, Canosa F, Pérez-Alberti A (2016) Dinámica geomorfológica del frente costero del valle de Teixidelo (NO Península Ibérica) entre 1945 y 2014. *Revista Geográfica del Sur* 7:34–46

Hose TA (2016) In: *geoheritage and geotourism a European perspective*. Boydell Press

Hose TA, Marković SB, Komac B, Zorn M (2011) Geotourism – a short introduction. *Acta geographica Slovenica* 51:339–342

Jorgenson J, Nickerson N (2016) Geotourism and sustainability as a business mindset. *J Hosp Mark Manag* 25:270–290

Kubalíková L, Kirchner K (2016) Geosite and geomorphosite assessment as a tool for geoconservation and geotourism purposes: a case study from Vizovická vrchovina highland (eastern part of the Czech Republic). *Geoheritage* 8:5–14

Lahuerta-Mouriño F & Lucas-Domínguez N (1990) Itinerario xeolóxico no norte de Galicia. *Diputación de Lugo*

Marcos A, Farias P, Galán G, Fernández FJ & Llana-Fúnez S (2002) In: *Variscan-Appalachian dynamics: the building of the late Paleozoic basement*. Geological Society of America, pp 143–162

Martínez-Catalán JR, Hatcher RD, Arenas R & Díaz García F (2002) *Variscan- Appalachian dynamics: the building of the late Paleozoic basement*. Geological Society of America 305p

Martínez-Catalán, JR, Arenas R, Abati J, Sánchez Martínez S, Díaz García F, Fernández Suárez J, González Cuadra P, Castiñeiras P, Gómez Barreiro J,

Díez Montes A, González Clavijo E, Rubio Pascual FJ, Andonaegui P, Jeffries TE, Alcock JE, Díez Fernández R & López Carmona A (2013) *Geología del Complejo de Cabo Ortegal y de las unidades relacionadas del basamento de Galicia: guía de campo*

Martínez-Graña AM, Goy JL, Cimarra CA (2013) A virtual tour of geological heritage: valourising geodiversity using Google Earth and QR code. *Comput Geosci* 61:83–93

Martínez-Graña AM, Serrano L, González-Delgado JA, Dabrio CJ, Legoinha P (2017) Sustainable geotourism using digital technologies along a rural georoute in Monsagro (Salamanca, Spain). *International Journal of Digital Earth* 10:121–138

AQ12

Mendía MS (2000) Petrología de la unidad eclogítica del Complejo de Cabo Ortegal (NW de España). *Nova Terra*, p 424

Migoñ P, Pijet-Migoñ E (2017) Viewpoint geosites — values, conservation and management issues. *Proc Geol Assoc* 128:511–522

Mikhailenko AV, Nazarenko OV, Ruban DA, Zayats PP (2017) Aesthetics-based classification of geological structures in outcrops for geotourism purposes: a tentative proposal. *Geologos* 23:45–52

Monterrubio, S.; Lunar, R. & Oyarzun, R.(1992). Mineralizaciones de cromoplatinoides y oro en los complejos polimetamórficos de Galicia. *Laboratorio Xeolóxico de Laxe. Serie Nova Terra*

Motte E, McInnes R (2019) Using artistic imagery to improve understanding of coastal landscape changes on the Rance Estuary (French Channel Coast). *Geoheritage*

Musila W, Todt H, Uster D, Dalitz H (2005) Is geodiversity correlated to biodiversity? A case study of the relationship between spatial heterogeneity of soil resources and tree diversity in a Western Kenyan Rainforest. Springer, US, pp 405–414

Newsome D, Dowling R (2010) *Geotourism: the tourism of geology and landscape*. Goodfellow Publishers Limited

Ólafsdóttir R, Dowling R (2014) Geotourism and geoparks---a tool for geoconservation and rural development in vulnerable environments: a case study from Iceland. *Geoheritage* 6:71–87

Ollero A (2017) Hidrogeomorfología y geodiversidad: el patrimonio fluvial. Ríos: hidrogeomorfología, problemática, rehabilitación. In: Ayuntamiento de Zaragoza

Puelles P (2004) Deformación, Metamorfismo y Exhumación de las Granulitas de Alta Presión de La Bacariza (Complejo de Cabo Ortegal, No España)

Pulido-Fernández M, Largar Timón D & García Marín R (2011) El geoturismo como estrategia de desarrollo en áreas rurales deprimidas: propuestas de geoparque Villuercas, Ibores, Jara (Extremadura). *Boletín de la A.G.E.*, pp 485–497

Reynard E (2008) Scientific research and tourist promotion of geomorphological heritage. *Geogr Fis Din Quat* 31:225–230

Ruban DA (2016) Representation of geologic time in the global geopark network: a web-page study. *Tourism Management Perspectives* 20:204–208

Santos I, Henriques R, Mariano G, Pereira DI (2018) Methodologies to represent and promote the geoheritage using unmanned aerial vehicles, multimedia technologies, and augmented reality. *Geoheritage* 10:143–155

Serrano Cañadas E & Ruiz Flaño P (2007) Geodiversidad: concepto, evaluación y aplicación territorial. El caso de Tiernes Caracena (Soria). *Boletín de la AGE*, pp 79–98

Świerkosz K, Koźma J, Reczyńska K, Halama M (2017) Muskau arch geopark in Poland (Central Europe)---is it possible to integrate geoconservation and geoeducation into biodiversity conservation? *Geoheritage* 9:59–69

Verde-Vilanova JR (2009) Influencia de los factores de formación y uso del suelo en las propiedades ándicas, formas y mecanismos de estabilización de carbono en suelos del noroeste de la Península Ibérica. *Universidade de Santiago de Compostela*

Višnić T, Spasojević B, Vujičić M (2016) The potential for geotourism development on the Srem Loess Plateau based on a preliminary Geosite Assessment Model (GAM). *Geoheritage* 8:173–180

Walliss J, Kok K (2014) New interpretative strategies for geotourism: an exploration of two Australian mining sites. *J Tour Cult Chang* 12:33–49

Wójtowicz B (2011) The possibility of development of tourism and education in areas of geological parks based on the opinion of students of geography UJK in Kielce. *Problemy Ekologii Krajobrazu*, pp 133–140

Zgłobicki W, Baran-Zgłobicka B (2013) Geomorphological heritage as a tourist attraction. A case study in Lubelskie Province, SE Poland. *Geoheritage* 5:137–149