When Science and Leisure Meet: A Geotourist Itinerary in Southern Tierra Del Fuego, Argentina

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Abstract Tierra del Fuego (Patagonia, Argentina) is a re-known place due to its location and beauty. These attributes have drawn attention to adventurers during centuries as well as to visitors from all over the world and also to local and foreign researchers during decades. Witness of this situation was the Sixth Argentine Congress of Quaternary and Geomorphology which took place on April, 2015. A field trip was organized within the frame of the Congress in order to expose the scientific knowledge of the region and to reveal several aspects of the uniqueness of Tierra del Fuego. This chapter proposes a geotourist itinerary in Southern Tierra del Fuego, taking into account the experience of the first part of day 1 of the corresponding field trip, that is, along the Ushuaia-Harberton transect. Geotourism is a modern way of tourism that focuses on experiencing the Earth geological and geomorphological features. In order to achieve this, special services and facilities can be organized, for instance guided visits, interpretative materials (such as booklets, signs, posters), viewpoints, thematic trails, among others. It is believed that this geotourist itinerary must start with the identification of georesources that may allow in the future the design of a product to enhance this transect singularities. In this sense this chapter aims to: (a) present geotourism as a modern way of tourism, (b) outline the geological and geomorphological setting of Southern Tierra del Fuego, (c) select and describe different georesources in the Ushuaia-Harberton

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transect using a data-sheet designed ad hoc, and (d) discuss about geotourism as a bridge between science and leisure and how the former can be used to upraise the latter.

Keywords Georesources · Geotourism · Argentina · Patagonia · Southern Tierra del Fuego

1 Introduction

The Isla Grande de Tierra del Fuego (Fig. 1) is located at the southern end of South America, between lat. 52° 27′ 14″–55° 04′ 36″S and long. 65° 05′ 31″–71° 46′ 05″W. It is divided into two administrations: the Republic of Chile west of the 68° meridian and the Republic of Argentina to the east of it. This island is the largest of those of the Fuegian Archipelago.

The unique geographical position of Tierra del Fuego attractive in itself (the southernmost part of a continental landmass in the world) is enhanced by extremely diverse geoheritage, including striking sceneries of different origin.

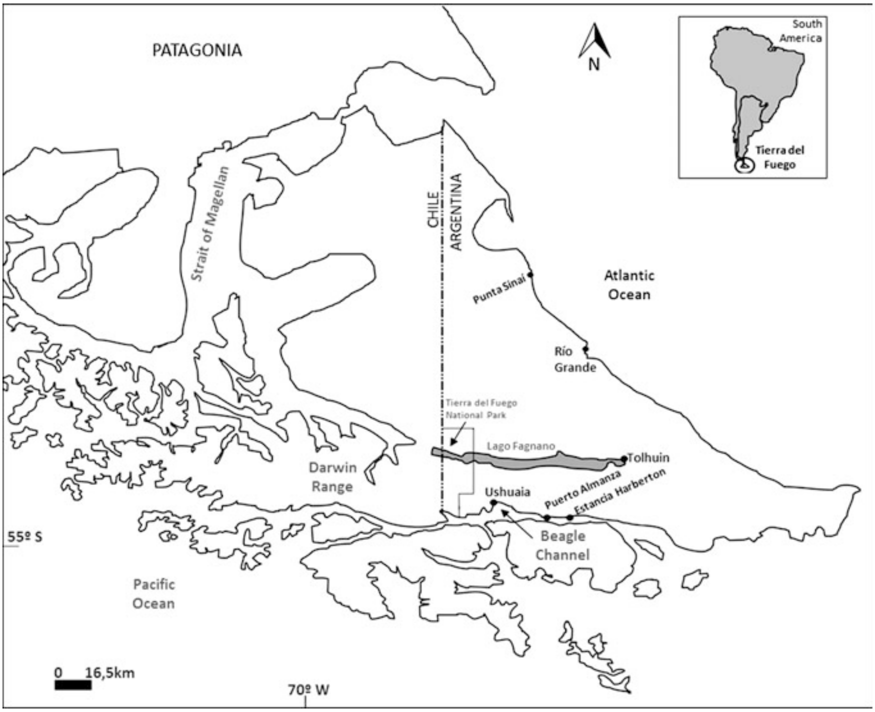


Fig. 1 General outline of Isla Grande de Tierra del Fuego

In Argentina, the province of Tierra del Fuego includes three urban locations: Ushuaia (the capital city), Tolhuin and Río Grande. The former was the venue of the Sixth Argentine Congress of Quaternary and Geomorphology which took place last April, 2015.

After three days of varied enriching lectures and even international conferences (some of which gave rise to this volume), a field trip was organized in the spirit of revealing the uniqueness of Tierra del Fuego: a geographical area which is geologically divided into two different tectonic plates: the South American plate to the North of the Magellan/Fagnano Fault and the Scotia plate to the South of it (e.g. Olivero and Martinioni 2001; González Guillot 2012) and was covered with big masses of ice during the Last Glacial Maximum which took place 24 ka B.P.—thousands of years before Present—(e.g. Rabassa 2008; Rabassa et al. 2005; Rabassa and Coronato 2007). These features bestow singularity to Tierra del Fuego and this will be exposed later.

The field trip organized within the cited Congress included an itinerary of three days around Tierra del Fuego in order to visit and to learn about special localities of geomorphological interest (Fig. 2), such as the Beagle Channel, the drumlin field of Harberton and Isla Gable, Lago Fagnano (day 1), the erratic boulder field of Punta Sinaí in northern Tierra del Fuego (day 2), Pleistocene and Holocene paleosoils (day 3) and many more features.

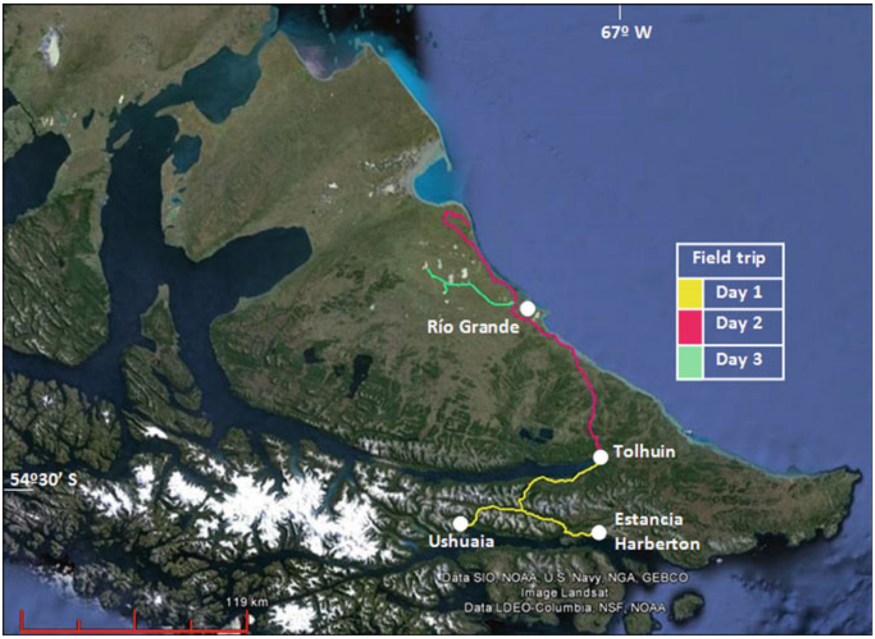


Fig. 2 Three-day field trip during the Sixth Argentine Congress of Quaternary and Geomorphology (Google Earth image)

Thanks to the local scientists and specialists that led the field trip, the participants were part of a geotourist practice, but without being aware of it. What is geotourism then? It is a modern way of tourism that focuses on experiencing the Earth geological features: the "geo" part of the term means geology and geomorphology and the "tourism" part of it means visiting geosites, learning, appreciating and engaging with nature and landscape (Dowling and Newsome 2010).

Martínez Fernández (2013) stated that there is a need to emphasize the appreciation and use of geological tourist attractions and in fact geotourism appreciates the abiotic environment in a natural landscape, without losing sight of its interrelations with biota and culture, but understanding that the latter have been historically more considered and integrated into tourist products and interpretative media. Under this perspective, geotourism offers a great opportunity to create new products in sparsely populated and faraway areas with incipient tourism and also to enrich the diversity of mountainous and coastal environments that currently concentrate more demand.

In this context, the itinerary proposed in this chapter starts in Ushuaia and continues through the National Road number 3 northwards and then takes place along provincial road "j" which leads to Puerto Almanza and then to Estancia Harberton (an "estancia" in Patagonia is an extensive private area or a large rural complex, similar to a ranch).

Along National Road 3, there are many winter sport centres which are also the starting point of several treks in the Fuegian Andes during the rest of the year. There are presently different viewpoints along the itinerary but only one site offers an interpretative board (in Valle Carbajal). The road "j" leads first to Puerto Almanza, a small fishery location, where there is incipient tourist infrastructure in the form of family restaurants, but for the time being these restaurants are mainly visited by local people rather than by tourists. Then, the route leads to Estancia Harberton. This is the oldest estancia in the Argentine sector of Tierra del Fuego. Its founder, Thomas Bridges, was an Anglican missionary who received a donation of land from the Argentine National Congress in acknowledgement for his work with the natives. Harberton is now managed by Thomas Goodall, a great-grandson of the founder. The estancia was declared an Argentine National Historical Monument in 1999 since it maintains its original simple buildings of wood covered with corrugated iron, its gardens, stone piers and terraces (January, 2016. Retrieved from http://www.estanciaharberton.com/historiaenglish.html). Originally, it operated with sheep (for wool) and cattle (for meat) but today, this well-known farm offers organized visits around the place: farm buildings, a vegetable garden, a graveyard, a museum of bones and a tea house. There is also a dock there from where small boats leave to visit an island nearby which is home of a Magellan penguin rockery, sometimes with occasional visitors of other sub-Antarctic species.

Apart from the tourist use of these roads, the transect draws attention to local and international scientists. Field and postgraduate courses organized in Ushuaia usually include this transect and different research projects were carried out in the area during the last three decades.

However, visitors just pass these roads, using them as a link between Ushuaia and Puerto Almanza or Estancia Harberton. Landscape performs as a great backdrop but most visitors enjoy it without merely noticing its components and dynamics. Despite this, through interpretative facilities, visitors may also acquire knowledge and understanding of the geology and geomorphology, and this is in fact the key goal in geotourism (Hose 1995). In addition, from a touristic point of view, Borla (1995) made a report classifying and analysing natural and cultural resources with ecotouristic potential. In her study the biotic information was particularly detailed, as it is usually understood that flora and fauna are the main source of interest for ecotourists.

In this sense, this chapter aims to: (a) present geotourism as a modern way of tourism, (b) outline the geological and geomorphological setting of Southern Tierra del Fuego, (c) select and describe different geosites in the Ushuaia-Estancia Harberton transect as well as their educational potential, (d) discuss geotourism as a bridge between science and leisure and how the former can be used to upraise the latter.

2 Geotourism as a Modern Way of Tourism

"The beauty of many geomorphological landscapes has long been recognized, starting from travelogues of ancient travellers and scientists. Today, many such landscapes, if easily accessible, are top tourist destinations, accommodating millions of visitors annually. They come to see the scenery, which in their eyes have outstanding universal value" (Migoń 2010, p. 11). However, geotourism is much more than just looking at landscapes.

Though modern geotourism has been practised for some time before, the term was actually undefined until the mid-1990s when Hose first definition appeared: geotourism is a form of tourism based on the provision of facilities and interpretation services that allows tourists to incorporate knowledge for understanding the geology and geomorphology of a site (including its contribution to the development of Earth Sciences) beyond the mere aesthetic appreciation (Hose 1995; in Hose 2012).

Conceptualizations of geotourism as a form of tourism have been reviewed by several authors. Since a universally accepted definition of the term does not exist, there are major disputes and confusions about its meaning (Hose 2012; Ollier 2012). As a result, it can be said that "when defining geotourism, two opposing conceptions emerge. Some scholars consider geotourism to be synonymous with geographical tourism, that is a form of tourism aimed at the integrative discovery of an area, with all its natural and human components […] The second view considers geotourism as a form of tourism aimed specifically at the discovery of the geoheritage of a region […]" (Reynard 2008, p. 225).

In this study, the latter view is adopted and although the aim of this paper is not to present the different approaches, some definitions will be given.

In Iran, Sadry (2009) suggested that geotourism is a type of tourism based on knowledge, preservation and interpretation of abiotic nature attributes. This idea was shared in Spain by Carcavilla et al. (2011) who added that geotourism must disclose the particular characteristics of the Earth to the visitors. Dowling and Newsome (2010, p. 232) stated that geotourism is a niche within nature tourism "that specifically focuses on geology and landscape. It promotes tourism to geosites and the conservation of geodiversity and an understanding of Earth Sciences through appreciation and learning. This is achieved through independent visits to geological features, use of geotrails and viewpoints, guided tours, geo-activities and patronage of geosite visitor centres". These authors fell within the sustainability paradigm emphasizing the importance of this type of development which is locally and economically beneficial, while geological heritage is protected. Moreover, Newsome and Dowling (2006) explained that geotourism can be seen as a system made of three subsystems: forms (landscapes, landforms, sediments, rocks and fossils), processes (tectonic activity, volcanic processes, weathering, erosion and deposition) and tourism (attractions, accommodation, tours, activities, interpretation, planning and management). In Brazil, Ruchkys (2007) understood that geotourism is the segment of tourism that has the geological heritage as the main attraction and at the same time seeks protection through conservation of resources and tourist awareness. He added that interpretation makes this heritage accessible to the lay public and promotes the development of Earth Sciences.

These various definitions converge at the following keywords: geological heritage, conservation, interpretation and learning. In this sense, Hose (2012) referred to the 3 G's of geotourism: (1) Geoconservation: an emergent geoscience that promotes the recognition of the importance of geosites for sustainable development education; (2) Geohistory: a systematic narrative of geological and geomorphological discoveries, events, personalities and institutions, and (3) Geointerpretation: the art or science of determining and communicating the meaning of geosites, events or locations.

As to the third G, geotourism uses, in order to achieve appreciation and learning, independent visits, thematic itineraries, viewpoints, guided tours, visitor centres and interpretation materials, such as posters. At this point, and following the different approaches, it can be said that the major difference between geotourism and other forms of tourism is precisely its educational function: to teach, to instruct and to explain clearly the repertoire of georesources in different sites (Millán Escriche 2011).

Finally, "geotourism as a type of nature tourism comes to fill an empty field on the use of geological resources of the landscape in Argentina" (Martínez Fernández 2013, p. 61). In Patagonia, for instance, there are incipient geotourism initiatives in arid and sparsely populated areas, particularly in northern Patagonia. Martínez Fernández (2013) stated that Patagonia has a great geotourist potential considering the strength of this destination in the national and international offer as well as its ever-increasing number of tourists. In the past two decades, progress has been made in "ecotourism" through the creation of new products and infrastructure of the term in the tourist supply; likewise, a geotourism discussion must be encouraged. If geotourism enhances the abiotic components of a natural landscape, then this perspective opens great possibilities to other Patagonian destinations as well as it promotes diversification of attractions in mountainous, tableland and coastal landscapes (Martínez Fernández 2013), presently still unused for these purposes.

3 Geographical Setting

The geological history of Tierra del Fuego began 150 Ma (millions of years) ago, when the area was covered by oceans from where volcanic islands emerged (González Guillot 2012). Between these islands and a continent to the north, there was an interior ocean with submarine volcanic activity that created new seabed (Stern and de Wit 2003). Some 50 Ma later, this interior ocean begun to narrow due to a change in the dynamics of the tectonic plates. The collision of these plates deformed the rocks causing faulting, folding and foliation and triggered mountain uplift (e.g. Fildani and Hessler 2005; Klepeis et al. 2010). This was the beginning of the formation of the Fuegian Andes which continued until the Miocene (Klepeis and Austin 1997; Ghiglione and Ramos 2005; Torres Carbonell et al. 2011). Successive stages of compression made the range grow in altitude and width. At the same time, major faults were formed, nowadays followed by the main valleys of the region, such as the Lago Fagnano, the Beagle Channel and the Carbajal-Tierra Mayor-Lashifasaj valleys. As these processes took place the interior ocean disappeared and the Tierra del Fuego archipelago completely emerged 2 Ma ago (e.g. Olivero and Malumián 2007).

Today, the boundary between the South American and Scotia plates (Fig. 3) is of the transform type (Diraison et al. 2000). The Magellan-Fagnano Fault extends from the Pacific Ocean through the Chilean side of Tierra del Fuego, and it continues into the Atlantic Ocean domain; the depression that occupies the Lago Fagnano follows this huge fault (e.g. Lodolo et al. 2003). The plates move along this fault with an average relative speed of 4–6 mm per year (Smalley et al. 2003, 2007; Mendoza et al. 2011). Movements along this fault, according to some authors (Cunningham et al. 1991; Kraemer 2003; Rapalini et al. 2015), have caused the curvature of the Andes in Patagonia which explains why the Fuegian Andes present a W–E trend, when the rest of the Southern Andes have a dominant N–S orientation.

According to Bujalesky (2007), the basement of the southern part of Tierra del Fuego is composed of pre-Jurassic highly deformed metamorphic rocks, covered by Late Jurassic to Early Cretaceous volcanic pyroclastic rocks and by Early Cretaceous, mildly metamorphosed, sedimentary rocks of marine origin. The northern part is composed of non-deformed Late Jurassic-Early Cretaceous rocks; the oldest exposed sediments are continental or marine Tertiary rocks, overlain by Pliocene-Pleistocene glacial deposits.

During the Quaternary, glaciations affected Tierra del Fuego (Fig. 4): five main lobes developed from an ice sheet in Darwin Range, Chile (55º S–69º W; 2000 m a. s.l.—meters above sea level—), spreading in all directions and following

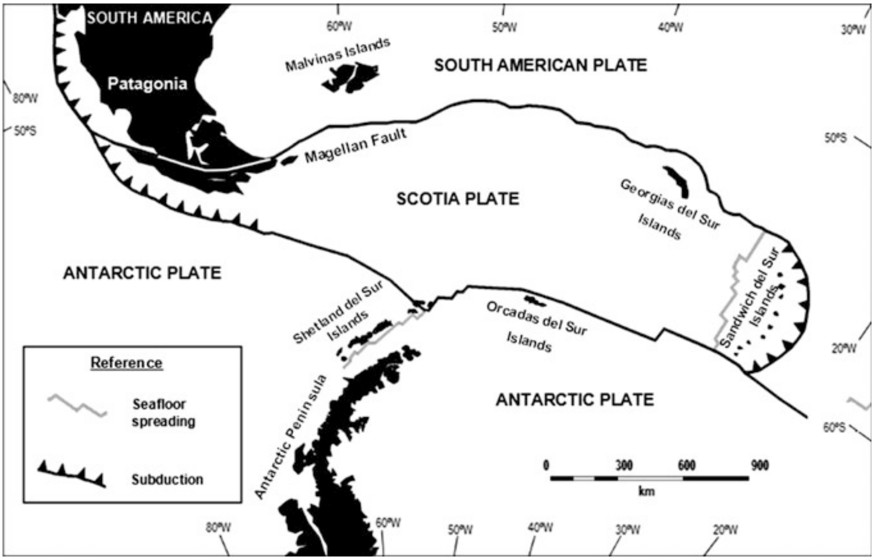


Fig. 3 Tectonic plates that affect Tierra del Fuego (modified from Bird 2003)

alignments and pre-existing fluvial valleys; small tributary glaciers occupied inner valleys (Rabassa et al. 2011; Rabassa and Coronato 2007). According to Rabassa et al. (2011), “five main glaciations have been mapped in the northern area, but only the last two have been recognized so far in the mountainous southern area”. In the former, submerged till, glaciofluvial deposits and erratic boulders have been recognized, whilst in the latter conspicuous moraines, outwash plains with kettles, drumlin fields, cirques, troughs and many other erosional and depositional landforms can be identified. The Last Glacial Maximum was attained around 24 ka B.P., and the ice recession started before 14.7 ka B.P. (Rabassa and Clapperton 1990).

These geographical characteristics impose low-hill topography, plateaus and closed depressions in the North of the Fuegian archipelago and a mountainous terrain in the South, separated by a transitional intermediate zone formed by hills, wide valleys and lake basins (Coronato 2014).

The topography, together with the latitudinal position of Tierra del Fuego and its closeness to Antarctica, which influence the climate, gives rise to three major biomes: steppe in the North, sub-Antarctic mixed forest and Andean desert in the South, and the Fuegian ecotone in the centre. All these factors determine five landscape units (Coronato 2007): steppe plains, mixed hills and valleys, forested mountains, peaty plains and coasts. Since the transect Ushuaia-Estancia Harberton is located in the “forested mountains” and “coasts” areas, only these two landscape units will be described.

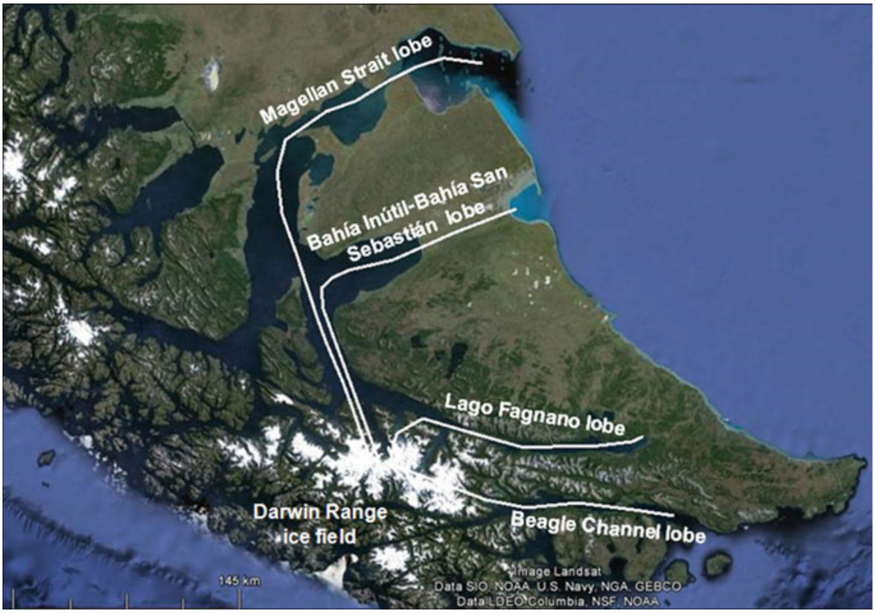


Fig. 4 Major ice lobes during the Quaternary glaciations, based on Coronato et al. (2004) (Google Earth image)

According to Coronato (2007, 2014), a mountainous topography dominates the south-western part of Tierra del Fuego. The Fuegian Andes, with W-E direction, form relatively low mountain ranges, reaching about 1000 m a.s.l. Slope steepness is considerable, and therefore, despite rather low altitude, there is a high mountain scenery with jagged peaks, rock slopes, deeply incised valleys and widespread talus. Metamorphic rocks of Palaeozoic and Mesozoic age and marine origin are stratified, folded and foliated. There are also some igneous rocks, both volcanic and plutonic. Mountain systems have been subject to minor faulting. All the landscape shows evidence of past ice modelling. Cirques, horns, truncated spurs and sharp edges are characteristic. Some glacial troughs are now occupied by lakes, whereas most of the valleys host peatbogs and *Nothofagus sp*. forest in the slopes, up to 600 m a.s.l., in the lower parts.

On the other hand, 525 km of two different coastlines describe Tierra del Fuego in the East and in the South. The former corresponds to the Atlantic Ocean coast and is situated in a stable geological area. The latter, where the transect takes place, corresponds to the Beagle Channel, situated in a seismic, tectonically active area, affected by several glaciations. High coasts in hard rocks with gravel beaches as well as low and terraced areas can be identified.

4 Ushuaia-Estancia Harberton Transect as a Geotourist Itinerary

Any geotourist itinerary must start with the identification of georesources that may allow in the future the design of a product to enhance the singularities of a transect.

Though the Ushuaia-Estancia Harberton transect offers more georesources, in this case the attention will be focused on the six most important ones (Fig. 5). The sites selected for this itinerary were all stopovers during the field trip of the Congress and are the result of an assessment and ranking process carried out during the senior thesis of the first author (Schwarz 2009), which included the design of three instruments for data collection: a fact sheet, a direct assessment sheet and a parametric assessment sheet. Some of these results were presented in other meetings (Schwarz et al. 2011; Schwarz 2013).

To describe each of the six georesources, a data-sheet was designed (Table 1), following recommendations when building a catalogue of sites of geological interest (Carcavilla et al. 2007). The sheet includes information about location (coordinates and access of the viewpoint and management), physiographic features (dimensions and altitude), lithology, type of use (economic, scientific, recreation, observation) and geodescription (formation, processes, age, among others). It also details what type of georesource is described, according to its structure (sedimentary, tectonic, hydrological or geomorphological) and materials (minerals, rocks, fossils or soils), what educational functions it has so as to learn about different geoprocesses and geosystems, which specific Earth Sciences could be promoted if geo-interpretation is offered, as well as any other information related to various aspects of nature and culture.

All the photographs included in the sheets (Tables 2, 3, 4, 5, 6 and 7) were taken by the first author during different field trips whereas all the sketches except one for

Fig. 5 Ushuaia-Estancia Harberton transect. Georesources: *1* Beagle Channel, *2* Valle Carbajal, *3* Gable island, *4* Drumlin field, *5* Bahía Cambaceres and *6* Harberton peatbog (Google Earth image)

Table 1 Data-sheet to describe georesources

<table>
<tr><td colspan="6">Georesource</td></tr>
<tr><td colspan="3">1. Location</td><td colspan="3" rowspan="9">5. Sketch</td></tr>
<tr><td>1.1. Coordinates</td><td colspan="2"></td></tr>
<tr><td>1.2. Access</td><td colspan="2"></td></tr>
<tr><td>1.3. Management</td><td colspan="2"></td></tr>
<tr><td colspan="3">2. Physiographic features</td></tr>
<tr><td>2.1. Dimensions</td><td colspan="2"></td></tr>
<tr><td>2.2. Altitude</td><td colspan="2"></td></tr>
<tr><td>3. Type of use</td><td colspan="2"></td></tr>
<tr><td>4. Lithology</td><td colspan="2"></td></tr>
<tr><td colspan="6">6. Photograph</td></tr>
<tr><td>7. Geodescription</td><td colspan="5"></td></tr>
<tr><td colspan="6">8. Type of georesource</td></tr>
<tr><td rowspan="4">8.1. Structure</td><td>8.1.1. Sedimentary</td><td></td><td rowspan="4">8.2. Materials</td><td>8.2.1. Minerals</td><td></td></tr>
<tr><td>8.1.2. Tectonic</td><td></td><td>8.2.2. Rocks</td><td></td></tr>
<tr><td>8.1.3. Hydrological</td><td></td><td>8.2.3. Fossils</td><td></td></tr>
<tr><td>8.1.4. Geomorphological</td><td></td><td>8.2.4. Soils</td><td></td></tr>
<tr><td>9. Educational functions</td><td colspan="5"></td></tr>
<tr><td>10. Geosciences promoted</td><td colspan="5"></td></tr>
<tr><td>11. Other information</td><td colspan="5"></td></tr>
<tr><td>12. References</td><td colspan="5"></td></tr>
</table>

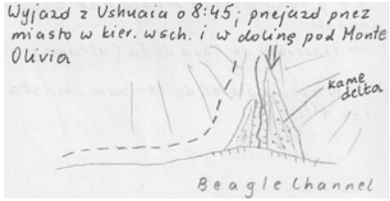
Schwarz (2016), doctoral thesis in preparation

georesource 3 were hand-drawn by the second author during the Congress field trip. Sketches include notes in Polish but these are translated into English below each respective sketch.

5 Linking Science and Leisure

The six georesources presented above are just a sample from a more extensive list of potential sites of interest. The transect Ushuaia-Estancia Harberton offers many more, such as Monte Olivia, Río Lasifashaj, Cerro Cornú, Bahía Brown and Bahía Harberton, among many others. All these natural attractions are already being used by the tourism industry, but as Manosso (2012) stated, the scientific contents offered to tourists should be more extensively explored so that these localities are not only appreciated for their aesthetic value. One way to achieve this is through thematic panels. Miranda et al. (2011) explained that these have a great effectiveness and give the chance to bring people to issues related to Earth Sciences. Panels give observers information about what they are looking at in a direct way. They are a great resource for geo-interpretation and geotourism, particularly in isolated localities.

Table 2 Georesource 1: Beagle Channel data sheet

Georesource 1: “Beagle Channel” (in Ushuaia)		
1. Location		5. Sketch
1.1. Coordinates	54° 48′ 18″S–68° 17′ 40″W	
1.2. Access	Direct access from the city of Ushuaia	
1.3. Management	Argentine Navy and National Coast Guard	
2. Physiographic features		
2.1. Dimensions	190 km long and 5 km average wide	
2.2. Altitude	0 m a.s.l.	
3. Type of use	Economic. Recreation. Scientific. Observation	 Departure from Ushuaia at 8:45, across the town towards the east and into a valley below Mt Olivia
4. Lithology	Along the north coast the “Deformed Complex of the Fuegian Andes” develops, which consists in its lower part of a metamorphic basement on which volcanic and sedimentary rocks of Jurassic age lie, which in turn are covered by layers of marine origin from Late Jurassic-Early Cretaceous. This set is folded and metamorphosed, as the result of intense seismic activity in the area.	
6. Photograph		

(continued)

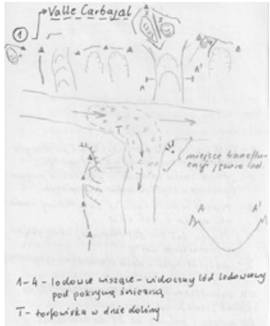
Table 2 (continued)

Georesource 1: "Beagle Channel" (in Ushuaia)					
7. Geodescription	A marine channel that connects the Pacific and the Atlantic oceans with a maximum depth of 280 m in the western area. Clear water with a temperature between 3 and 7 °C. Estuarine dynamic, with semidiurnal microtidal regime and a less-than-2-m range tide. The Channel occupies a tectonic valley that was modelled by outlet glaciers several times during the Pleistocene. The paleo-glacier Beagle flowed from W to E during the LGM, along 200 km and with an average width of 10 km and 1200 m of thickness in its central part. The retreat of the glaciers started 14.7 ka B.P.; the progressive inflow of sea water started about 8.2 ka B.P. The islands and islets in the channel show signatures of subglacial erosion; the channel coasts present different landforms of glacial origin, including a drumlin field and frontal moraines that show the maximum position of the ice front during the LGM. In 2008, the Argentine Mining and Geological Survey declared the Beagle Channel as a Site of Geological Interest considering it a significant example of the expression of endogenous and exogenous processes.				
8. Type of georesource					
8.1. Structure	8.1.1. Sedimentary		8.2. Materials	8.2.1. Minerals	
	8.1.2. Tectonic	x		8.2.2. Rocks	x
	8.1.3. Hydrological	x		8.2.3. Fossils	
	8.1.4. Geomorphological	x		8.2.4. Soils	
9. Educational functions	Geo-interpretation may allow visitors to learn: – about tectonic plates; – about changes in global climate and the dynamics of glacial times; and – about major changes in the sea level.				
10. Geosciences promoted	Geomorphology Geology				
11. Other information	The channel name derives from the British navy vessel used in Fitz Roy's hydrographic expeditions to South America which included a famous trip with the young Charles Darwin on board. Sea-mammals and birdlife including penguins live in the islands and islets of the Channel. Underwater kelp forests. *Nothofagus sp.* forest develops from the shore up to 600 m a.s.l. Archaeological sites 8000 years old, on the shore and higher old beaches. Different parts of the coastline are protected by the national and local governments.				
12. References Borla and Vereda (2001), Borla (1995), Coronato (2007), Rabassa et al. (2000), Coronato et al. (1999), Rabassa and Coronato (2007), Bujalesky et al. (2008)					

Table 3 Georesource 2: Valle Carbajal data sheet

Georesource 2: "Valle Carbajal"		
1. Location		5. Sketch
1.1. Coordinates	54° 44′ 03″S/68° 10′ 52″W	
1.2. Access	17 km from Ushuaia, along route "3"	
1.3. Management	Public. Part of a natural reserve.	
2. Physiographic features		
2.1. Dimensions	23 km long, 2.5 km maximum width	
2.2. Altitude	From 150 to 1000 m a.s.l.	
3. Type of use	Economic. Recreation. Observation.	
4. Lithology	Lemaire Formation: phyllites and slates highly deformed, of Late Jurassic-Early Cretaceous age.	

5. Sketch



Site of transfluence of a glacial tongue [right]
1–4 Hanging glaciers—glacier ice seen beneath snow cover
T—peat bogs in the valley floor

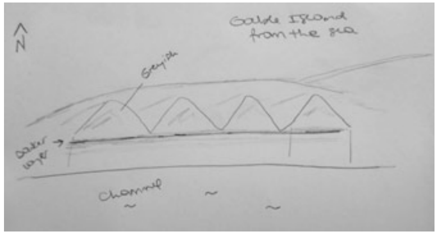
6. Photograph

(continued)

Table 3 (continued)

Georesource 2: "Valle Carbajal"					
7. Geodescription	The Carbajal valley is traversed by a 100 km long major thrust fault, which includes adjacent valleys (Tierra Mayor and Lasifashaj) with a W-SE direction. During the Quaternary glaciations, this valley was occupied by a main outlet glacier and many alpine glaciers that descended from the Vinciguerra, Valdivieso and Alvear ranges, forming an integrated glacial system. During the LGM, a transfluent ice lobe flowed to the south through the Olivia valley to the Beagle Channel. Today, the Carbajal valley shows several erosional landforms such as sharp edges, horns, cirques, hanging valleys and truncated spurs. No depositional landforms associated with the LGM can be identified here since this was the ice accumulation zone, except for some till deposits at the bottom of the valley. Some slopes show geomorphical evidence of rock and debris slides.				
8. Type of georesource					
8.1. Structure	8.1.1. Sedimentary		8.2. Materials	8.2.1. Minerals	
	8.1.2. Tectonic	x		8.2.2. Rocks	x
	8.1.3. Hydrological			8.2.3. Fossils	
	8.1.4. Geomorphological	x		8.2.4. Soils	
9. Educational functions	Geo-interpretation may allow visitors to learn: – about tectonics; – about changes in global climate and the dynamics of glacial times; – how a glacier can erode the surface and leave landforms; and – about weathering and landslides.				
10. Geosciences promoted	Geology Geomorphology Glaciology				
11. Other information	The Olivia river runs along the valley. Part of the valley is today occupied by shallow lakes and peatbogs. Trees 3.7 ka old were found in these bogs. Presence of birdlife and beavers that affect river flows. Viewpoint with interpretative sign and starting point of several trails.				
12. References Sarandon (1997), Rabassa and Coronato (2005), Roig and Collado (2004)					

Table 4 Georesource 3: Gable island data sheet

Georesource 3: "Gable island"		
1. Location		5. Sketch 
1.1. Coordinates	54° 52′ 18″S/67° 33′ 43″W	
1.2. Access	77 km from Ushuaia: 40 km along Route "3" (paved), 35 along Route "j" (dirt road) and 2 more km westwards along the Beagle Channel shore.	
1.3. Management	Private. It is part of Estancia Harberton.	
2. Physiographic features		
2.1. Dimensions	25 km^2	
2.2. Altitude	0–92 m a.s.l.	
3. Type of use	Observation.	Gable Island from the sea Greyish (upper part), Darker layer, Channel (bottom)
4. Lithology	Bedrock is composed of metamorphosed sedimentary rocks, highly folded and deformed (Yahgán formation) and covered by Late Pleistocene glaciogenic sediments that are overlain by alluvial, aeolian and littoral sequences of Holocene age	
6. Photograph		

(continued)

Table 4 (continued)

Georesource 3: "Gable island"					
7. Geodescription	This island is part of the Beagle Channel Islands affected by subglacial erosion and it corresponds to the first drumlin field described in Argentina, being composed of 70 drumlins and 5 rocky drumlins, which are up to 2.5 km long, 0.3 km wide and up to 92 m a.s.l high. The internal structure is composed of a lower basal till unit, an ice-contact stratified-drift glaciofluvial unit, a glacio-lacustrine unit and a glacially-reworked lacustro-till unit on top. The west facing drumlins suffer strong erosion by sea waves which leave a "gable" shape and gorges. The inter-drumlin depressions are occupied by mires, peatbogs and lagoons.				
8. Type of georesource					
8.1. Structure	8.1.1. Sedimentary	x	8.2. Materials	8.2.1. Minerals	x
	8.1.2. Tectonic			8.2.2. Rocks	x
	8.1.3. Hydrological			8.2.3. Fossils	
	8.1.4. Geomorphological	x		8.2.4. Soils	
9. Educational functions	Geo-interpretation may allow visitors to learn: – about changes in global climate and the dynamics of glacial times; and – about coastal landforms.				
10. Geosciences promoted	Geomorphology				
11. Other information	In the past, Estancia Harberton used to have cattle in the island.				
12. References Rabassa et al. (1990), (2000), Coronato (2007), Coronato et al. (1999), Rabassa and Coronato (2007)					

Table 5 Georesource 4: Drumlin field data sheet

Georesource 4: "Drumlin field"	
1. Location	
1.1. Coordinates	54° 51′ 17″S–67° 28′ 19″W
1.2. Access	75 km from Ushuaia: 40 km along Route "3" (paved) and 35 along Route "j" (dirt road).
1.3. Management	Private.
2. Physiographic features	
2.1. Dimensions	25 km long
2.2. Altitude	From 0 to 100 m a.s.l
3. Type of use	Economic. Observation.
4. Lithology	Yaghán formation. Subglacial till deposits.

5. Sketch

4. Drumlin field
(by the road to Estancia Harberton, the road goes across drumlins)
Inter-drumlin depressions are partly filled by lakes [lower]

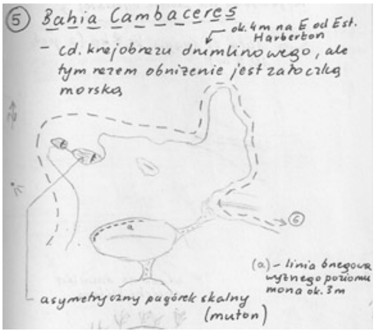
6. Photograph

(continued)

Table 5 (continued)

Georesource 4: "Drumlin field"					
7. Geodescription	Drumlins are both erosional and depositional subglacial landforms with an inverted-spoon shape that shows direction of ice flow. They typically appear in groups and were formed during the Pleistocene glaciation. The drumlins on the shore have a W–E direction while the drumlins at the mountain foot have a NW–SE direction. These different alignments indicate the existence of two ice lobes: the paleo-glacier Beagle and the paleo-glacier Lasifashaj. Several rivers traverse the field: Lasifashaj, Cambaceres, Varela, among others.				
8. Type of georesource					
8.1. Structure	8.1.1. Sedimentary	x	8.2. Materials	8.2.1. Minerals	x
	8.1.2. Tectonic			8.2.2. Rocks	x
	8.1.3. Hydrological			8.2.3. Fossils	
	8.1.4. Geomorphological	x		8.2.4. Soils	
9. Educational functions	Geo-interpretation may allow visitors to learn: – about changes in global climate and the dynamics of glacial times; and – how glacial deposits look like.				
10. Geosciences promoted	Geomorphology				
11. Other information	Presence of "flag" trees that show the prevailing direction of the wind (SW–NE).				
12. References Coronato (2007), Rabassa et al. (2000), Coronato et al. (1999), Rabassa and Coronato (2007), Arocena Bongiorni (2002), Antonione (2006)					

Table 6 Georesource 5: Bahía Cambaceres data sheet

<table>
<tr><td colspan="3">Georesource 5: “Bahía Cambaceres”</td></tr>
<tr><td colspan="2">1. Location</td><td rowspan="9">5. Sketch

Drumlin landscape continues (approximately 4 km to the east from Estancia Harberton), but the inter-drumlin depression is now a marine bay.
Asymmetric rock knob (“roche moutonnee”) [lower left]
Shoreline of a higher sea level stand, c. 3 m [lower right]</td></tr>
<tr><td>1.1. Coordinates</td><td>54° 52′ 17″S–
67° 17′ 34″W</td></tr>
<tr><td>1.2. Access</td><td>95 km from Ushuaia: 40 km along Route “3” (paved) and 55 along Route “j” (dirt road).</td></tr>
<tr><td>1.3. Management</td><td>Private.</td></tr>
<tr><td colspan="2">2. Physiographic features</td></tr>
<tr><td>2.1. Dimensions</td><td>It has a wide mouth of 830 m, whereas its penetration is around 1300 m.</td></tr>
<tr><td>2.2. Altitude</td><td>0 m a.s.l.</td></tr>
<tr><td>3. Type of use</td><td>Recreation. Scientific.</td></tr>
<tr><td>4. Lithology</td><td>Yahgán formation: Early Cretaceous. Deep marine metamorphosed sedimentary rocks of marginal basin (black slate, tuff and sandstone).</td></tr>
<tr><td colspan="3">6. Photograph
</td></tr>
<tr><td>7. Geodescription</td><td colspan="2">Inter-drumlin depression with NW–SE direction. Separated from the Bahía Varela through a peninsula and connected by a 50-m-wide tombolo.
Ice-moulded bedrock hills around the bay.
Marine clear water with an average temperature of 6.5 °C and a tidal range of 1.16 m.
Uplifted Holocene beaches.</td></tr>
</table>

(continued)

Table 6 (continued)

<table>
<tr><td colspan="7">Georesource 5: "Bahía Cambaceres"</td></tr>
<tr><td colspan="7">8. Type of georesource</td></tr>
<tr><td rowspan="4">8.1. Structure</td><td>8.1.1. Sedimentary</td><td></td><td rowspan="4">8.2. Materials</td><td>8.2.1. Minerals</td><td></td></tr>
<tr><td>8.1.2. Tectonic</td><td></td><td>8.2.2. Rocks</td><td>x</td></tr>
<tr><td>8.1.3. Hydrological</td><td>x</td><td>8.2.3. Fossils</td><td></td></tr>
<tr><td>8.1.4. Geomorphological</td><td>x</td><td>8.2.4. Soils</td><td></td></tr>
<tr><td>9. Educational functions</td><td colspan="5">Geo-interpretation may allow visitors to learn:
– about changes in global climate and the dynamics of glacial times;
– about major changes in the sea level;
– how tides affect shores; and
– about coastal landforms.</td></tr>
<tr><td>10. Geosciences promoted</td><td colspan="5">Geomorphology</td></tr>
<tr><td>11. Other information</td><td colspan="5">Presence of molluscs, algae and marine birdlife.
Archaeological sites dated back to 8000 years ago, on the shore and higher old beaches.
Natural shelter for sailboats.</td></tr>
<tr><td colspan="6">12. References
Borla (1995), Coronato et al. (1999)</td></tr>
</table>

Panels add valuable information to traditional itineraries, and they are an excellent complement to tour guides, who can use these posters as a practical and attractive tool to report on geological topics. At the same time, the involvement of different stakeholders enables a fundamental objective: to disseminate and promote the conservation of geological heritage (Miranda et al. 2011).

Apart from the interpretative panels that could be arranged in each of the six georesources described, we propose the following initiatives:

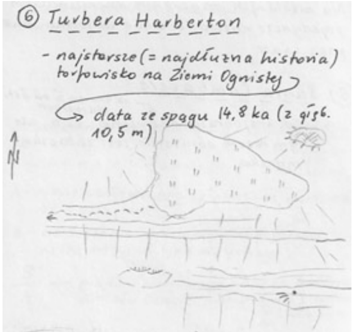
– Georesource 1: "Beagle Channel"

A bike and trekking path could be designed connecting different bays along the northern shore of the channel. In the path, different stopovers could include posters explaining landscape formation as well as quotations from explorers and scientists of the area, such as Charles Darwin, who described the Beagle Channel as a beautiful sheet of water surrounded by mountains, rounded and not very high, of clayey shale, covered by a dense forest (Darwin 2006).

– Georesource 4: "Drumlin field"

An interpretation centre could be built, including different rooms dedicated to the evolution of the Fuegian landscapes, such as the formation of the Andes, the Last Glaciation and the current interglacial time. Information about climate changes and glacial landforms should be given. This would be the first inter-drumlin interpretation centre in the world and could offer services like stores, bookshops and coffee-shop, among others.

Table 7 Georesource 6: Harberton peatbog data sheet

Georesource 6: "Harberton peatbog"		
1. Location		5. Sketch
1.1. Coordinates	54° 52′ 54″S/67° 13′ 43″W	
1.2. Access	100 km from Ushuaia: 40 km along Route "3" (paved) and 60 along Route "j" (dirt road).	
1.3. Management	Private.	
2. Physiographic features		
2.1. Dimensions	0.4 km × 0.2 km	
2.2. Altitude	25 m a.s.l.	
3. Type of use	Scientific.	
4. Lithology	Holocene peat that occupies a bedrock hollow excavated in rocks belonging to the Yaghán formation, Early Cretaceous.	6. Harberton peatbog The oldest (longest history) peat bog in Tierra del Fuego—date from the bottom of peat 14.8 ka (from 10.5 m depth)

6. Photograph

7. Geodescription	Inter-drumlin depression occupied by about 11 m of *Sphagnum sp*. peatbog, without external drainage and circular shape. The base of bog was dated to 14.8 ka B.P. Paleo-climatic and environmental research resource.

8. Type of georesource					
8.1. Structure	8.1.1. Sedimentary		8.2. Materials	8.2.1. Minerals	x
	8.1.2. Tectonic			8.2.2. Rocks	
	8.1.3. Hydrological	x		8.2.3. Fossils	
	8.1.4. Geomorphological	x		8.2.4. Soils	x

(continued)

Table 7 (continued)

Georesource 6: "Harberton peatbog"	
9. Educational functions	Geo-interpretation may allow visitors to learn: – about changes in global climate; and – how a glacial depression can be occupied by peatbogs.
10. Geosciences promoted	Geomorphology Geology
11. Other information	Oldest peatbog studied in Tierra del Fuego.
12. References Roig (2004), Rabassa et al. (2005), Roig and Roig (2007), Arocena Bongiorni (2002)	

– Georesource 6: "Harberton peatbog"

Special visits with local scientists could be arranged to this locality in order to let visitors walk on the peatbog. Together with the specialists, interpretation of the available data could promote better understanding of natural events, which could be used for scientific research. Thematic panels explaining the importance of bogs should include information on how paleoclimate history can be rebuilt after studying this georesource.

Migoń (2010, p. 9) explained that "… natural scenery, which is essentially a combination of landforms of different sizes, shapes, origins, and ages, can be captivating". However, and according to Manosso (2012), some natural resources are not easily seen by visitors, but with this type of scientific intermediation they can become visible and decoded. Turning a traditional visit into a geotourist one could overcome this difficulty. How? Through specific background research, at both the theoretical and application levels (Reynard 2008). Geology and Geomorphology appear to be the most suited sciences to achieve this, since "… where an untrained eye sees mainly the beauty of a physical landscape, geomorphologists go a step further, trying to answer how and why such a natural beauty has come into being" (Migoń 2010, p. 9).

Using science for geo-interpretation must be seen as an opportunity to enrich the experience of both residents and visitors, giving them the chance to learn and understand physical natural processes, which would definitely make tourists appreciate better the Fuegian landscapes and lead to a more conservationist look. Moreover, through the implementation of the proposed initiatives, visitors would be informed and educated about local heritage, and this would probably reinforce the identity of the residents. This transect could be a proper scenery for academic practices where scientific knowledge would be spread. Approaching visitors to Earth Sciences could even awaken scientific talents.

Furthermore, since the existence of the first Fuegian geotourist itinerary could draw attention of more visitors, not only it would broaden the local tourist offer, but also alleviate other tourist saturated areas such as Tierra del Fuego National Park.

Besides, if this transect becomes a geotourist one, conservation and maintenance practices should be carried out, keeping roads in a good state, designing new paths, arranging panels and brochures. All these could derive into the generation of new local workforce.

When referring to Patagonia (and Tierra del Fuego is included) Rabassa (2008) said: "Being a land of adventure, mystery and opportunity, it is one of the least populated regions in the world and the southernmost territories with temperate continental ecosystems. It is today a chosen destination by thousands of tourists that flock from all over the world, searching for the well-promoted Patagonian enchantments". Geotourism could definitely take advantage of these strengths.

6 Conclusions

Geographical, geological and geomorphological settings of Tierra del Fuego make it an attractive geotourist destination.

Following Reynard (2008), "by definition leisure is central for tourists. On the other hand, geotourism has among its objectives the education of Earth Sciences. The challenge is, therefore, to develop tools that combine these two aspects, leisure and education, to disseminate knowledge on geosciences towards a large public" Reynard 2008, p. 228).

It is believed that through this geotourist itinerary in Southern Tierra del Fuego, science and leisure could be linked in a way that the forms of enhancement proposed are addressed in order to take advantage of the educational functions of each site, as well as to promote conservation, dissemination of scientific disciplines and generation of economic activities.

Taking the transect Ushuaia-Estancia Harberton and focusing on natural scenery does not necessarily mean that geotourism is practiced. However, it is assumed that this route could be turned into a geotourist itinerary if special services and facilities were organized in order to provide an enriched experience to visitors through the initiatives proposed and other innovative proposals to develop Earth Sciences and to promote sustainable economic activities involving the local population. All these would not only value each georesource as a concrete spatial unit but the whole transect between Ushuaia and Estancia Harberton, generating a sustainable development opportunity.

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