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Geotourism and Interpretation of Geomorphology in Mountain Tourism

The Case of UNESCO Swiss Alps Jungfrau-Aletsch

Jonathan Bussard and Emmanuel Reynard

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Introduction

- 1 Since its rise in the second half of the 18th century, Alpine tourism has undergone major changes (Guérin, 2006). The Alps were first admired in summer from belvederes, which access was facilitated by the construction of railways and altitude hotels, particularly in the central part of the Alps, between the Bernese Oberland and the Mont Blanc massif, via the Valais. The showcase offered by the development of mountaineering from the 1850s onwards and the health benefits of the “good air” of the mountains led to the development of a tourist industry in various Alpine regions, particularly in Switzerland (Tissot, 2000). From 1950 onwards, skiing became hegemonic in the regions equipped with ski lifts, thus transforming tourism practices which would mainly take place in winter and around sport and leisure activities. Today, because of climate change, snow cover is becoming increasingly unpredictable in the mountains and the winter sport-based tourism model seems to be reaching its limits (Bourdeau, 2009). This raises the question of how to adapt tourist activities to this new context. In order to keep their customers, many destinations are diversifying the range of recreational activities offered by proposing new leisure, sport, festive or cultural activities which are not exclusive and can coexist spatially and temporarily (Salim *et al.*,

2021). The tourist promotion of local heritage—natural, cultural, gastronomic, etc.—and the development of scientific tourism are part of this evolution towards more diversity.

- 2 The labelling of many Alpine territories—UNESCO World Heritage property, regional nature park, biosphere reserve, geopark—, with a double objective of protection of local heritage (natural and cultural) and regional development through the economic use of the heritage in the field of tourism (Hobléa *et al.*, 2017), reflects the growth of heritage tourism in mountain regions. In the Swiss Alps, a part of the Bernese Oberland and the Upper Valais was the first natural site in the Alps to be inscribed on the UNESCO World Heritage List in 2001, with the name Swiss Alps Jungfrau-Aletsch. This inscription can be seen as a willingness to reinforce the protection of nature while encouraging the diversification of tourist activities based on the heritage interest of the site. As for other heritage sites (for example in the Chablais Geopark [Perret, 2014] or in the Bauges Geopark [Hobléa, 2014]), scientific research in the field of geosciences has been decisive in the heritage awareness phase (“prise de conscience patrimoniale”, Di Méo, 2008). It highlighted the heritage values of this site, based in particular on the exceptional geological heritage (“geoheritage”) of the region, shaped by the presence of the largest glacier in the Alps (the Aletsch Glacier), by a remarkable glacial geomorphology and a distinctive geological structure, at the origin of spectacular landscapes (see chapter 3).
- 3 This article examines how scientific knowledge is integrated into the geoheritage discovery offers. Through a detailed analysis of the interpretation offers of geomorphological heritage in and around the UNESCO Swiss Alps Jungfrau-Aletsch property, we show how the interest revealed by the work of scientists, especially that of the glacial landscapes, is integrated into the offers for visitors. This is especially interesting in the context of climate change, a current societal concern that strongly affects glacial landscapes (Salim and Ravanel, 2020). Are specific offers being proposed, including interpretation, and by which types of stakeholders? Do these offers allow us to overcome the simple aesthetic appreciation of landscapes to reveal their scientific and heritage interest? To what extent is the dissemination of the knowledge based on documented data accessible to various audiences? Finally, the aim of this contribution is to position the offers inventoried in relation to the field of geotourism, considered here as a form of scientific tourism.

Geotourism, a Form of Scientific Tourism

- 4 Geotourism is a specific form of nature tourism focused on the discovery of geology and geomorphology. It is developed in a context of heritage recognition of geological objects, whose heritage values are revealed by scientific research, and aims to encourage the protection of abiotic nature by raising visitors’ awareness (Pralong, 2006; Hose, 2012; Hose and Vasiljević, 2012; Newsome and Dowling, 2010, 2018). To achieve this, interpretive products and services (as defined by Tilden, 1957) are developed so that visitors can acquire knowledge and understanding of the geology and geomorphology of a site beyond a mere aesthetic appreciation (Hose, 1995). Interpretation aims to create or strengthen the link between the public and the site visited to enhance the attraction, interest and pleasure of the visit (Martin, 2013: 16). In the French-speaking literature, the term *médiation scientifique*, which acts as an interface between the audience and scientific knowledge (Viallette *et al.*, 2021), is one of

the closest synonyms for interpretation, used in the English-speaking literature. The use of the concept of *médiation scientifique* aims to break with that of scientific popularisation, a practice that would be limited to the vertical transfer of academic knowledge to the lay public, without concern for the questionings and expectations of the public, which would thus widen the gap between science and society and would only partially achieve its educational objectives (Martin, 2013; Bergeron, 2016; Las Vergnas, 2016; Vialette *et al.*, 2021). On the contrary, the *médiation scientifique* attempts to answer questions about contemporary societal issues, to encourage reflexivity and perspective, and to give meaning to disciplinary knowledge (Kramar, 2012). Although the motivations and practices are different on the principle, the aim in both cases is to bring scientific knowledge within the reach of a wide audience by means of different types of explanations, definitions or illustrations with, in the case of the *médiation*, the idea of interaction between knowledge and the public. In the context of the heritage recognition of geological objects, the presence of interpretation facilities is a necessary condition for the existence of geotourism (Duval and Gauchon, 2010), as it prevents the aesthetic and spectacular characteristics of many geoheritage sites, referred to by Cayla *et al.* (2012) as the “mask of the picturesque”, from concealing the heritage interest of the sites (Reynard, 2021). Interpretation also enhances the interest of the visit when it gives visitors the opportunity to live an original tourist experience.

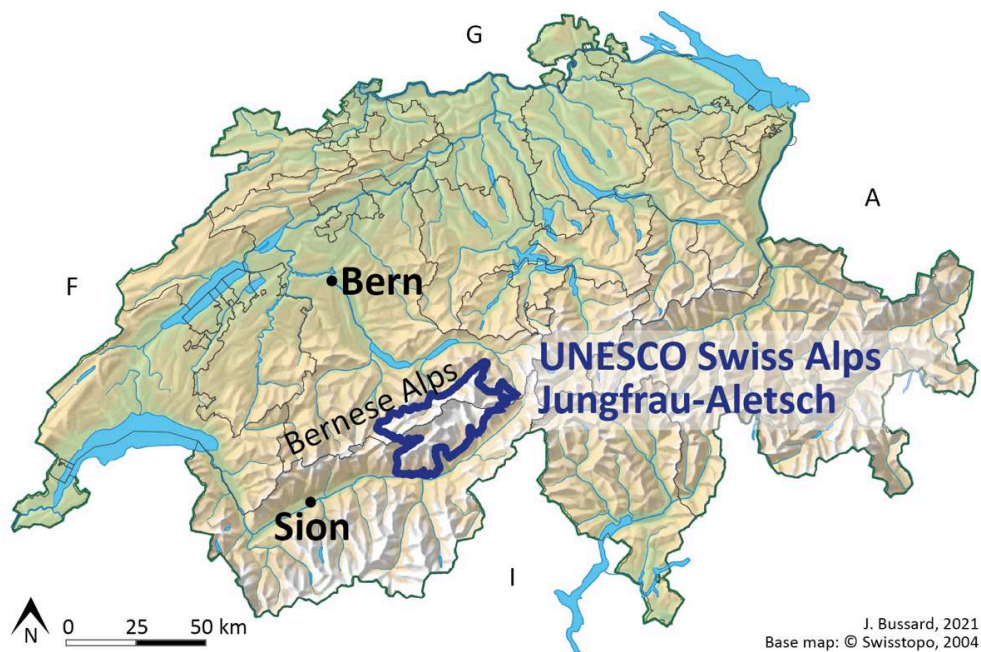
- 5 There is a proximity between geotourism and certain forms of scientific tourism. Geotourism is indeed part of what Mao and Bourlon (2011: 96) call “cultural tourism with a scientific content”, whose main objective is the transfer of scientific knowledge to a large public through the provision of guidance. These two forms of tourism, scientific tourism and geotourism, have in common the fact that they contribute to the process of heritage recognition and thus to the protection and promotion of different types of heritage. Unlike geotourism, which focuses mainly on topics related to geology and geomorphology, cultural tourism with a scientific content can be broader and integrate other disciplines. Geotourism, on the other hand, is distinct from scientific research tourism (“researchers as travellers”, Slocum *et al.*, 2015), where the tourist-researcher is directly involved in scientific research activities. In practice, and particularly in the Alps, the tourism promotion of geoheritage, considered as a territorial resource (Bétard *et al.*, 2017; Hobléa *et al.*, 2017), has led to a sharp increase in the number of geology and geomorphology interpretation offers (Calya, 2009).

Study Site

- 6 The UNESCO Swiss Alps Jungfrau-Aletsch property is located in the Bernese Alps (Fig. 1), in the cantons of Valais and Bern (Switzerland). It belongs to the Aare Massif, which consists of autochthonous crystalline basement into which the highest peaks of the region are carved (Finsteraarhorn, 4274 m a.s.l.; Aletschhorn, 4193 m a.s.l.; Jungfrau, 4158 m a.s.l.), marginally covered at the northern and western ends of the site by Helvetic sedimentary cover (Labhart, 2007). The latter forms the impressive north faces of the Eiger, Wetterhorn and Engelhörner, made of massive Upper Jurassic limestone (Zumbühl *et al.*, 2021). This site contains the largest continuous ice surface in the Alps as well as the Aletsch Glacier, which is the longest (20.7 km) and largest (79 km²) glacier in the Alps (Holzhauser, 2021). The specificity of the site is related to remarkable glacial landscapes, marked by the glaciers themselves, but also by many

forms of erosion or deposition that attest to the past fluctuations of the glaciers. The U-shaped valley of Lauterbrunnen is a particularly spectacular example of glacial erosion, with almost flat valley floor surrounded by high vertical rock walls crossed by several waterfalls. The rapid evolution of the landscape due to glacier retreat as a result of global warming is another characteristic of the site (Zumbühl *et al.*, 2021). The Aletsch Glacier, for example, could lose between 60% and almost 100% of its volume by 2100 under different greenhouse gas emission scenarios (Jouvet and Huss, 2019), leading to the increase of slope instability (Kos *et al.*, 2016) and the formation of new lakes in the valley floors (Haeberli *et al.*, 2017). Permafrost degradation is another consequence of climate change that has significant effect on landscape evolution (Haeberli *et al.*, 2017).

Figure 1. Location of the UNESCO Swiss Alps Jungfrau-Aletsch property



- 7 The inscription of the Swiss Alps Jungfrau-Aletsch property on the World Heritage List in 2001 was justified on the basis of three UNESCO criteria: (vii) the outstanding aesthetic importance, (viii) the geological and geomorphological interest, and (ix) the ecosystem diversity. This inscription occurred long after the site was developed as a tourist destination. The villages located around the UNESCO perimeter (Grindelwald, Lauterbrunnen, Wengen, Bettmeralp, etc., Fig. 2) have indeed a long tradition of tourism, marked at the beginning of the last century by the construction of the Jungfrau railway (1912), which brings visitors over 3400 m a.s.l. through the north face of the Eiger to the accumulation zone of the Aletsch Glacier. With the exception of the Aletsch Forest, declared an “absolute forest reserve” and a “site to be protected” in 1933 (Decision of the State Council of the Canton of Valais n°451.111) in order to protect the fauna and flora of this forest located on the periphery of the glacier, it was only in 1983 that the site was included in the Federal Inventory of Landscapes and Natural Monuments (ILNM), at the end of a long inventory process at the national level, thus concretising the efforts of heritage protection on the scale of the entire site. The perimeter of the ILNM site was determined in such a way that it did not include the

infrastructure of the surrounding ski areas, which in the 1970s and 1980s already largely corresponded to today's ones.

- 8 The perimeter of the UNESCO property, which largely overlaps with the ILMN site, also excludes the surrounding villages and tourist resorts, as well as the vast majority of tourist infrastructure and ski lifts. In order to better reflect the whole range of interpretation offers of the geomorphology of the UNESCO property, we have retained all the offers located within a radius of 3 km around its limits (Fig. 2). Beyond this empirically established limit, the offers no longer correspond to objects located in the UNESCO property.

Methodology

- 9 Our demonstration is based on three distinct steps detailed below:
 1. the selection of interpretation offers,
 2. the evaluation of the selected offers and
 3. the analysis and categorisation of the offers (typology).
- 10 For the selection phase, we identified all interpretation offers related to geomorphology (three purely geological offers—crystal exhibitions without interpretation—were not considered). Only indirect interpretation offers (Martin, 2013) with physical support (panel, brochure, museum, mobile application, audio) were retained, as offers without physical support (guided tours) are more difficult to inventory in a systematic way (they are not necessarily offered on a regular basis). After a first inventory of the offers presented on the internet, field visits (direct observation) were carried out in summer 2021 and contacts were made with the tourist offices of the region and the managers of the UNESCO property in order to guarantee the exhaustiveness of the inventory.
- 11 The evaluation of the offers was carried out on the basis of a multi-criteria grid, used to evaluate each offer separately. The choice of criteria was based on methodological proposals for the evaluation of geotourism offers (Martin *et al.*, 2010; Martin, 2013; Martin and Regolini, 2013) and on the evaluation grid used by the association *Nature—Culture & Tourism* (NCT) for the evaluation of didactic trails in Valais (<https://www.sentiers-decouverte.ch>). The evaluation grid (Tab. 1) is composed of 38 criteria grouped into five categories: general information, site, content of the offer, form/medium, accessibility and management. Unlike the above-mentioned works, the main objective of the approach is not to evaluate the formal quality of the offer, but rather to provide information on the position of interpretation in the content of the offer, the presence of research results, the degree of popularisation, the degree of detail of the information presented, etc.

Table 1. Evaluation grid for geomorphology interpretation offers

General information	<p>01 Name</p> <p>02 Place name</p> <p>03 Municipality</p> <p>04 Type</p> <p>05 Year of creation</p> <p>06 Website</p>
Site	<p>07 Geomorphosite(s) visited</p> <p>08 Geomorphosite(s) presented</p> <p>09 Geoscientific interest of the site(s): [integrity, rarity, representativeness, paleogeographic interest; average of criteria from 0 to 1, see Reynard <i>et al.</i> (2007)]</p> <p>10 Scientific research on this site(s)</p> <p>11 Didactic interest of the site(s): [1: landforms difficult to “read”, inactive; 2 landforms easily readable, inactive; 3: landforms easily readable, active/dynamic]</p>
Content of the offer	<p>12 Themes addressed</p> <p>13 Number of themes addressed</p> <p>14 Place of geomorphology in relation to all themes addressed [1: limited (<33% of the content); 2: moderate (33%-66%); 3: important (> 66%)]</p> <p>15 Generality/detail of information about geomorphology: [1: very general (some general information, without explanation); 2: general; 3: relatively detailed; 4: detailed; 5: very detailed (very detailed and illustrated explanations)]</p> <p>16 Quality of the scientific content: [1: poorly documented; 2: partially documented; 3: well documented]</p> <p>17 Popularisation of scientific aspects: [1: not popularised (use of scientific vocabulary, without explanation); 2: partly popularised; 3: popularised; 4: popularised and simplified; 5: very popularised and simplified (no scientific vocabulary, simple explanations)]</p> <p>18 Content-site consistency (consistency of the informative content and the site[s] presented): [1: not consistent; 2: little consistency; 3: moderate consistency; 4: consistent; 5: very consistent (identifies the specific features of the site very well)]</p> <p>19 Consistency of the itinerary (consistency of the chosen itinerary and the specificities of the site): [the locations visited allow 1: none; 2: little; 3: partly; 4: well; 5: very well to visualize features of geoscientific interest]</p> <p>20 Are scientific research results presented?</p> <p>21 Does the information presented demonstrate the geoscientific interest of the site? [1: no (no mention of the geoscientific interest); 2: very little; 3: partly; 4: widely; 5: yes (many explanations present with references to research)]</p>

Form/medium	<p>22 Type(s) of interpretation medium(s)</p> <p>23 Media used</p> <p>24 Visual impact of the installations on the landscape: [0: no impact, 1: low, 2: medium, 3: high]</p> <p>25 Formal quality of the offer (qualitative assessment)</p>
Accessibility and management	<p>26 Walking time</p> <p>27 Elevation gain</p> <p>28 Difficulty of the trail: [0: no walking; 1: easy, T1; 2: moderate, T2-T3; 3: difficult, T4]</p> <p>29 Proximity to parking lots and public transport stops: [1: not very accessible (> 1h walk); 2: easily accessible (10-60 minutes walk); 3: very accessible (<10 minutes walk)]</p> <p>30 Seasonality</p> <p>31 Regularity</p> <p>32 Price</p> <p>33 Language(s)</p> <p>34 Author (s)</p> <p>35 Manager(s)/operator(s)</p> <p>36 Visibility of the offer on the web: [1: not visible on the web; 2: little visible; 3: well visible and relayed on the websites of tourist offices or other portals]</p> <p>37 Visibility of the offer on the site: [1: no indication; 2: little indication; 3: well indicated]</p> <p>38 Associated activities: [sport (hiking), cultural (museum), contemplative (viewpoint), recreational, educational, etc.]</p>

- 12 Most criteria are evaluated numerically on a scale of 1 to 3 or 1 to 5. For the interpretation of the results, we first performed a univariate analysis in order to reflect the general characteristics of the inventory, and then a bivariate and multivariate analysis, for which linear correlation coefficients were calculated with a view to group offers with similar characteristics and to obtain a typology of the offers.

Results

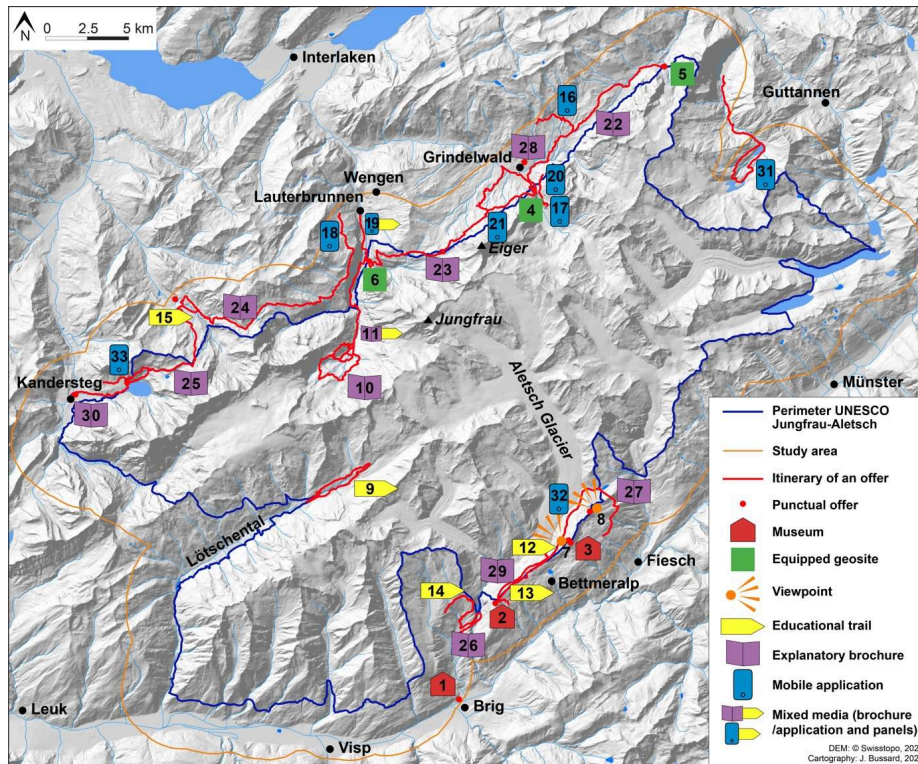
- 13 The results of the inventory show, on the one hand, that there are numerous offers of interpretation of geomorphology in the UNESCO Swiss Alps Jungfrau-Aletsch property and its immediate surroundings and, on the other hand, that these offers are very diverse. This diversity is expressed both in terms of form (type of medium, length of the proposed itinerary, etc.) and content (degree of detail and popularisation, number of themes addressed, etc.).

Univariate Analysis—Main Characteristics of the Inventory

- 14 Thirty-three offers satisfying the selection criteria were inventoried (Tab. 2): 10 explanatory brochures, 8 mobile applications, 5 educational trails, 3 museums, 3

equipped geosites, 2 viewpoints and 2 offers combining panels with a brochure or an application. The most frequently presented geomorphosites are glaciers and their proglacial margins, in particular the Aletsch Glacier (12 offers, Fig. 3) and the Lower Grindelwald Glacier (6 offers), but also other lesser-known glaciers. Only 9 offers are mainly oriented towards non-glacial sites; they present the waterfalls of the Lauterbrunnen Valley (3 offers), the structural landscape of the northern slope of the Eiger–Mättenberg–Wetterhorn (3), the Fisistock and Oeschinensee rockfalls (2) and the Rosenloui gorge (1). The geoscientific interest of the presented sites (assessed according to the method of Reynard *et al.*, 2007) is very high (average of 0.87/1), as they are particularly representative of the regional geomorphology (0.98/1) and are overall very well preserved (integrity: 0.93/1). The Rosenloui Gorge and the Trümmelbach Waterfalls, which have been tunnelled and built up to provide access for visitors (Fig. 4), are the two worst preserved sites (the facilities significantly diminish the integrity of these sites). Glacial sites, which are numerous in this inventory, are often of high palaeogeographical interest (Grandgirard, 1997; Reynard *et al.*, 2007), as glacial traces are witnesses of the Earth’s history and climate. As the vast majority of the sites are very “readable” (clearly visible and distinct landforms, shaped by active geomorphological processes), their didactic interest is high (average score of 2.8/3).

Figure 2. Map of the geomorphological interpretation offers around the UNESCO Swiss Alps Jungfrau-Aletsch property according to the type of medium.



The numbers refer to the list in Table 2.

Table 2. List of inventoried offers, municipality, type and main geomorphosite presented. The names are given in English where they exist and in German where they do not.

N°	Name	Municipality	Type	Main geomorphosite presented
1	World Nature Forum	Naters	Museum	Aletsch Glacier
2	Villa Cassel—exhibition “Gletscherschwund— Klimawandel—Energiewende”	Riederalp	Museum	Aletsch Glacier
3	Eiswelt Bettmerhorn Faszination Aletschgletscher	Bettmeralp	Museum	Aletsch Glacier
4	Gletscherschlucht	Grindelwald	Equipped geosite	Lower Grindelwald Glacier system
5	Rosenloui Gletscherschlucht	Schattenhalb	Equipped geosite	Rosenloui Gorge
6	Trümmelbachfälle	Lauterbrunnen	Equipped geosite	Trümmelbach Waterfalls
7	Ice Terrasse Bettmerhorn	Bettmeralp	Viewpoint	Aletsch Glacier
8	Rundweg Eggishorn	Fiesch	Viewpoint	Aletsch Glacier
9	Sehen & verstehen. Ein Themen—und Lehrpfad zu Klima und Gletscherlandschaft	Blatten	Educational trail	Langgletscher proglacial margin
10	Bestand hat nur der Wandel	Lauterbrunnen	Explanatory brochure	Proglacial margins of Tschingel, Breithorn and Schmadri Glaciers
11	Themenwege UNESCO Welterbe Schweizer Alpen Jungfrau-Alesch	Lauterbrunnen	Panels, explanatory brochure	Holdri, Schmadribach and Talbach Waterfalls
12	Themenweg Grosser Aletschgletscher im Wandel der Zeit	Riederalp	Educational trail	Aletsch Glacier
13	Themed Adventure Trail (Ridge Path) from Moosfluh to Riederfurka	Riederalp	Educational trail	Aletsch Glacier
14	Eis Zeit Aletsch Gletscher	Naters	Educational trail	Aletsch Glacier
15	Alpwirtschaft—und Naturlehrpfad auf der Griesalp	Reichenbach i.K.	Educational trail	Gamchi Glacier

16	Climate Guide Jungfrau A—Bort-Unterer Lauchbühl	Grindelwald	Mobile application	Lower and Upper Grindelwald Glaciers
17	Climate Guide Jungfrau B—Pfinstegg-Bäregg	Grindelwald	Mobile application	Lower Grindelwald Glacier system
18	Climate Guide Jungfrau D—Grütschalp—Mürren	Lauterbrunnen	Mobile application	Grütschalp Landslide
19	Jungfrau Region SmarTrails—Wanderung im Tal der 72 Wasserfälle	Lauterbrunnen	Mobile application, panels	Waterfalls of the valley of Lauterbrunnen
20	UNESCO Themenwege—SmarTrails—Klimawandel hautnah	Grindelwald	Mobile application	Lower Grindelwald Glacier system
21	UNESCO Themenwege—SmarTrails—Unterwegs im Wasserschloss Europas	Grindelwald	Mobile application	Lower Grindelwald Glacier system
22	Via GeoAlpina 1. Rosenluis-Grindelwald	Grindelwald, Schattenhalb, Meiringen	Explanatory brochure	North face of Eiger—Mättenberg—Wetterhorn (main thrust of Helvetic nappes)
23	Via GeoAlpina 2. Grindelwald—Lauterbrunnen	Grindelwald, Lauterbrunnen	Explanatory brochure	North face of Eiger—Mättenberg—Wetterhorn (main thrust of Helvetic nappes)
24	Via GeoAlpina 3. Mürren—Griesalp	Lauterbrunnen, Reichenbach	Explanatory brochure	Main thrust of Helvetic nappes
25	Via GeoAlpina 4. Griesalp—Kandersteg	Reichenbach, Kandersteg	Explanatory brochure	Blüemlisalp Glacier
26	Hydrologische Exkursionen in der Schweiz 2.1 Gletscher und Wasserkraftnutzung Belalp—Blatten bei Naters	Naters	Explanatory brochure	Aletsch Glacier
27	Hydrologische Exkursionen in der Schweiz 2.2 Gletscher und Wasserversorgung Riederalp—Fiescheralp	Riederalp, Bettmeralp, Fieschertal, Fiesch	Explanatory brochure	Aletsch Glacier
28	Gentle and wild—the valley of Grindelwald—UNESCO brochure	Grindelwald	Explanatory brochure	Lower Grindelwald Glacier system

29	Ice streams in the Aletsch region—UNESCO brochure	Riederalp, Bettmeralp, Fiesch	Explanatory brochure	Aletsch Glacier
30	Encounters at the Lötschberg—UNESCO brochure	Kandersteg, Reichenbach	Explanatory brochure	Rockfalls of Fisistock and Oeschinensee
31	My Swiss Alps—Hiking Tour to the Gauli Glacier	Innertkirchen	Mobile application	Proglacial margin of Gauli Glacier
32	My Swiss Alps—Hiking along the Aletsch Glacier	Riederalp, Bettmeralp, Fieschertal, Fiesch	Mobile application	Aletsch Glacier
33	My Swiss Alps — The rock arena around the Oeschinen lake	Kandersteg	Mobile application	Rockfalls of Fisistock and Oeschinensee

Figure 3. Sign on the educational trail “Themenweg Grosser Aletschgletscher im Wandel der Zeit” (n° 12), close to the Aletsch Glacier, the most frequently presented geomorphosite.



Photo: J. Bussard, 2021

Figure 4. Path leading into the Rosenlauri Gorge (n° 5), dug with dynamite in 1901-1902.

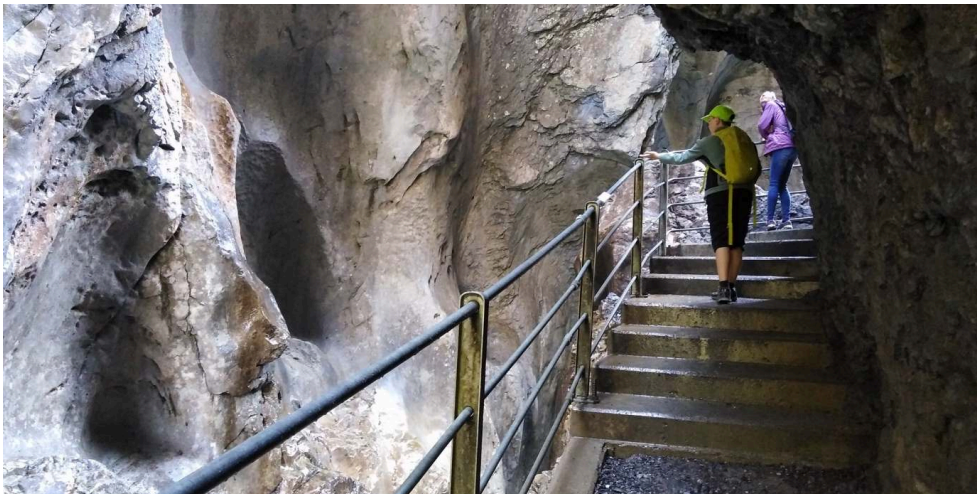


Photo: J. Bussard, 2021

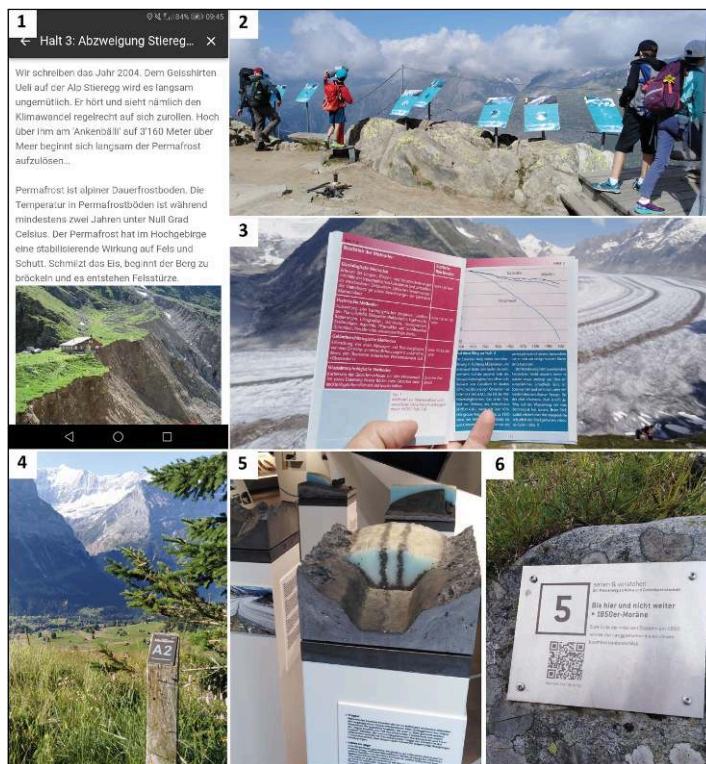
- 15 Each offer covers between one and nine topics; geomorphology, glaciology and geology are often combined with other topics such as regional history, local fauna and flora or the Alpine economy, but also with closely related topics such as climatology (especially on the issue of climate change), hydrology and natural hazard management. Geomorphology plays a major role (> 66% of the content) in more than half of the offers.
- 16 Two thirds of the offers have a well-documented content, and this can be explained by the involvement of scientists in the interpretation process. The degree of detail and the popularisation of the geomorphological aspects vary greatly (Tab.3). The large majority of the proposed itineraries allow a good or very good visualisation of the features of geoscientific interest. In half of the offers (16), the geoscientific interest is demonstrated at least to a wide extent (presence of explanations and references to research work), while 10 offers do not demonstrate it, or only very slightly.

Table 3. Content of the offers (number of occurrences for each category)

Detail of information about geomorphology		Popularisation of scientific aspects		Consistency of the itinerary		Demonstration of the geoscientific interest	
Very general	3	Not popularised	1	None	3	No	3
General	8	Partly popularised	9	Little	3	Very little	7
Relatively detailed	6	Popularised	11	Partly	3	Partly	7
Detailed	10	Popularised and simplified	9	Well	6	Widely	9
Very detailed	6	Very popularised and simplified	3	Very well	18	Yes	7

- 17 Thirteen offers were produced directly by scientists, 8 by the management centre of the UNESCO property, 5 by tourist offices (two of which in collaboration with the management centre of the UNESCO property), 4 by private individuals, 2 by a ski lift company and one by the association for nature conservation Pro Natura. Tourist offices are rarely authors of the content of the offers; they are, however, more present in the management of these offers. Conversely, scientists, who are often authors, are less present in the management of the offers, this task being delegated to the tourist offices in certain cases. The offers managed by scientists are relatively discreet, whereas the offers managed by the tourist offices are generally much more visible on the site (presence of signs and indications) and are well relayed on the Internet.

Figure 5. Different examples of geoscientific interpretation offers



(1) screenshot of the trail "Klimawandel hautnah" (Grindelwald) on the mobile application *SmarTrails* (offer n°20, see Table 2), (2) "Ice Terrasse", on a viewpoint at the Bettmerhorn (Bettmeralp, offer n°7), (3) brochure "Gletscher und Wasserversorgung Riederalp–Fiescheralp", part of the collection *Hydrological excursions in Switzerland* (offer n°27), (4) post of the itinerary A of the mobile application "Climate Guide Jungfrau" between Bort and Unterer Lauchbühl (Grindelwald, offer n°16), (5) model of a glacier valley in the World Nature Forum Museum in Naters (offer n°1), (6) sign of the educational trail "sehen & verstehen. Ein Themen–und Lehrpfad zu Klima und Gletscherlandschaft", accompanied by a brochure, in the proglacial margin of the Langgletscher (Blatten, Lötschental, offer n°9).

Photos: J. Bussard, 2021

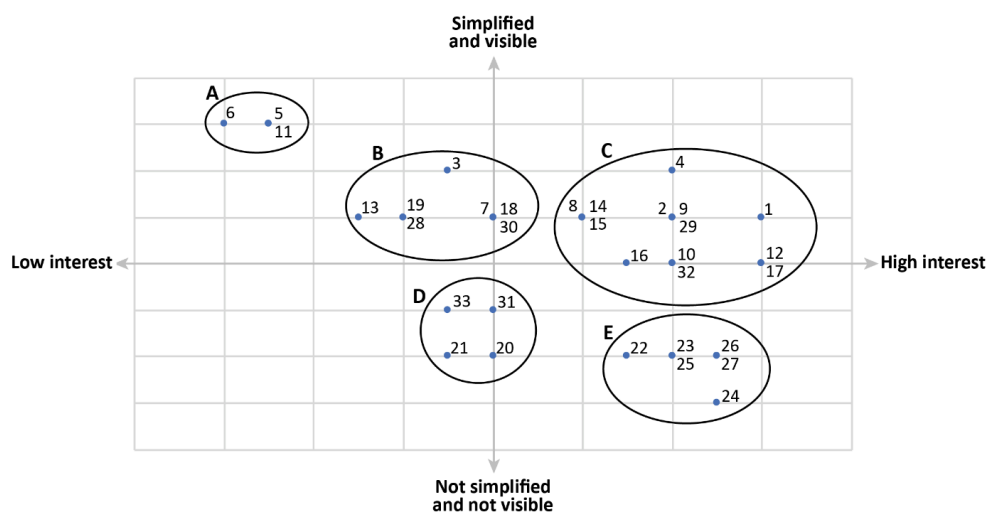
Bi- and Multivariate Analysis—Towards a Typology of Offers

- 18 A cross-reading of the evaluation criteria based on linear correlation coefficients (r) enables a more precise reading of the results. The strongest correlation ($r = 0.91$) is observed between the degree of detail (criterion n°15) and the demonstration of the geoscientific interest of the site (n°21). The detailed offers are also those whose

scientific content is best documented ($n^{\circ}16$; $r = 0.71$) and in which geomorphology ($n^{\circ}14$) is often more prominent ($r = 0.52$). On the other hand, the detailed offers are generally less popularised ($n^{\circ}17$; $r = -0.57$). The offers that most clearly demonstrate geoscientific interest are those with the best documented scientific content ($r = 0.65$), which give an important place to geomorphology ($r = 0.55$), but which are generally less popularised ($r = -0.51$) and slightly less visible on-site ($n^{\circ}37$; $r = -0.31$). A correlation between the degree of popularisation and on-site visibility is also observed ($r = 0.66$).

- 19 This analysis of the strongest correlations allows us to establish two groups of criteria which, in general, are correlated with those in the same group and inversely correlated with those in the other group. These are, on the one hand, the demonstration of geoscientific interest, the degree of detail, the quality of scientific content and the place of geomorphology (horizontal axis in Figure 6), and on the other hand, the degree of popularisation and the visibility on-site (vertical axis). Figure 6 shows where the 33 offers of the inventory are situated on these two axes, which are composed of the sum of the scores for the criteria of the two groups mentioned above.

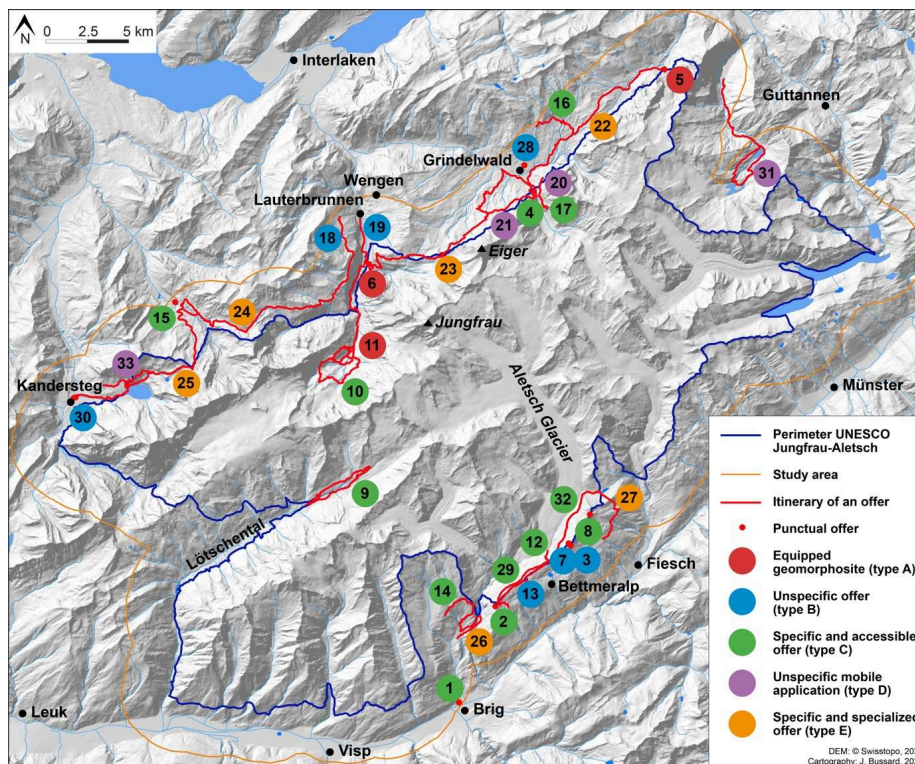
Figure 6. Classification of the offers according to two axes: vertical axis = demonstration of scientific interest + degree of detail + quality of content + place of geomorphology; horizontal axis = degree of popularisation + visibility on-site. The numbers refer to the list in Table 2. The five types of offer (A, B, C, D, E) are described in the text.



- 20 Type A (Fig. 4) includes offers having few geoscientific explanations, but which are clearly visible and whose content is very simplified. These are mainly **equipped geomorphosites** (gorges, waterfalls). Type B (Fig. 5-2) gathers offers that are visible and well popularised, but whose explanations are not very detailed, not very focused on geomorphology, and sometimes not very well documented and that only partially demonstrate the geoscientific interest of the site. For this reason, they can be described as **offers with little specificity** or distinctiveness. Type C (Fig. 5-4, 5-5 and 5-6) includes offers that are visible, popularised and interesting in terms of geoscientific content. These comprise the two paying museums (Fig. 5-5), several educational trails and two audio guides edited by scientists. Type C offers could be described as **specific and popularised offers**. Type D (Fig. 5-1) consists of offers with a moderate interest in geoscientific content and which are not very visible or popularised. These four offers have in common that they are mobile applications; their visibility on site is inexistent, as there are no particular indications about them. Type D offers are **unspecific mobile**

applications. Finally, type E (Fig. 5-3) brings together offers that are interesting from the point of view of their geoscientific content, but that are hardly visible and popularised. These six offers are all edited and managed by scientists. They are therefore mainly addressed to an informed public and can be qualified as **specific and specialised geotourism offers**. The summary map (Fig. 7) shows the location of the 33 offers as well as their belonging to the categories of offers described here.

Figure 7. Map of the geomorphological interpretation offers around the UNESCO Swiss Alps Jungfrau-Aletsch property according to the type of offer.



The numbers refer to the list in Table 2.

Discussion

- 21 The diversity of indirect interpretation offers, whose form, content and geographical distribution are very heterogeneous, raises the question of whether they all belong to the field of geotourism—and to that of scientific tourism. The place given to interpretation depends very much on the type of offer considered: the specific and popularised offers (type C) put interpretation at the heart of their content and scientists are often involved in the realisation of the offer. They therefore play their role as an interface between the public and geoscientific knowledge, which places them in the field of geotourism. Conversely, the brief descriptions proposed in the less specific offers (types A, B and D) only slightly contribute to the dissemination of knowledge produced by geoscientists. Should they therefore be considered as geotourism offers that participate in the heritage recognition process, or rather as strategies for marketing the site, as in the case of the Gorges de la Fou (French

Pyrenees), where development was carried out with little regard for geoheritage aspects, without any interpretation or landscape protection (Suchet, 2010)?

Aesthetic Value Versus Interpretation

- 22 Geomorphosites are often described as natural monuments of great aesthetic value (Reynard, 2021). This is particularly the case in the UNESCO Swiss Alps Jungfrau-Aletsch property: its “exceptional aesthetic importance” is one of the selection criteria for the property. The aesthetic value of Alpine glacial landscapes seems to be predominant in the motivations of visitors (Salim and Ravanel, 2020). Glacial landscapes known for their particular beauty thus attract visitors who are potentially interested in learning more about the geomorphological characteristics of the visited sites. However, while the aesthetic and spectacular character of a site attracts visitors to geoheritage sites, it also carries the risk of concealing the geoscientific interest of these sites (Reynard, 2021). This brings up the question, raised by Calya *et al.* (2012), of how to overcome the “mask of the picturesque” which tends to overshadow the other heritage interests of a site. The unspecific offers (types A, B and D), representing more than 40% of the offers in the inventory, are in this sense probably insufficient, as they do not, or only partially, demonstrate the geoscientific interest of the sites. In the case of equipped geomorphosites, such as gorges and waterfalls, with practically no interpretation (type A), the economic use largely outweighs heritage considerations. It is therefore difficult to speak of geotourism in this case.

Must-see and Forgotten Sites

- 23 The geographical distribution of indirect interpretation offers (Fig. 7) shows that the Aletsch Glacier receives a great deal of attention, especially in the category of specific and popularised offers. The content of these offers is therefore not particularly original and the information presented is sometimes redundant, but they do raise questions about the consequences of climate change, confronting visitors with the evidence of glacier retreat. The Grindelwald and Lauterbrunnen region, at the foot of the Jungfrau, also has a high number of offers. The offers located in these two regions—Aletsch and Jungfrau, which are the most visited in the study area—are those which potentially reach the largest audience. They can therefore play a significant role in raising visitor awareness (Reynard and Coratza, 2016), with the condition that the interpretation integrates the heritage dimensions.
- 24 Conversely, some sites are not promoted at all, even though their geoscientific interest is high. These include the hanging glacier valleys of the southern ramp of the Lötschberg (north of Visp, Fig. 7), which are included in the inventory of Swiss Geotopes (<https://www.geotope.ch>), the Gasteretal (south-east of Kandersteg) and the Grimsel region (between Guttannen and Münster), whose glacial heritage, among other things, is remarkable. These sites are part of the World Heritage area and are described in the Federal Inventory of Landscapes and Natural Monuments of national importance. This shows that heritage recognition is not necessarily accompanied by tourism development.

Conclusion

- 25 This article examines the offers of indirect interpretation of the geomorphological heritage of the UNESCO Swiss Alps Jungfrau-Aletsch property. The 33 offers inventoried have very diverse characteristics, both in terms of form and content. Half of them succeed in demonstrating the geoscientific interest of the sites presented, in a more or less detailed and popularised manner. In this case, interpretation allows us to reveal their heritage dimension and overcomes the “mask of the picturesque” (Cayla *et al.*, 2012), which tends to conceal the scientific interest of the sites behind their aesthetic characteristics. These offers, fully integrated into the field of geotourism, also question visitors about the consequences of climate change by providing keys to understand glacial landscapes affected by the retreat of glaciers, increase in slope instability, etc. On the other hand, more than 40% of the offers do not demonstrate, or only partially, the heritage interest of the sites presented. In some cases, the tourist use is not accompanied by the awareness of heritage, thus excluding the concerned offers from the field of geotourism as defined in the literature.

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ABSTRACTS

The spectacular landscapes of the site Swiss Alps Jungfrau-Aletsch (Bernese Alps), inscribed on the UNESCO World Heritage List since 2001, are recognised for their high scientific interest in the field of geomorphology. The heritage recognition of their geomorphological characteristics by various actors favours the development of geotourism, a form of tourism that aims to diversify the offer of tourist activities while raising visitors' awareness of the heritage value of the sites, through the implementation of interpretation facilities. This article proposes an analysis of the interpretation offers of the geomorphology in the region, evaluated and categorised on the basis of a multi-criteria grid in order to observe to what extent they achieve these two objectives. The 33 offers inventoried have very diverse characteristics, both in their form and in their content. Half of them succeed in demonstrating the scientific interest of the sites presented. In such cases, interpretation makes it possible to reveal their heritage dimension and to overcome the "mask of the picturesque" which tends to conceal the scientific interest of the sites behind their aesthetic characteristics. On the other hand, in some cases, the economic activation of the resources is not accompanied by the awareness of the heritage value, which excludes the offers concerned from the field of geotourism.

Les paysages spectaculaires du site Alpes suisses Jungfrau-Aletsch (Alpes bernoises), inscrit depuis 2001 sur la liste du patrimoine mondial de l'UNESCO, sont reconnus pour leur intérêt scientifique très élevé dans le domaine de la géomorphologie. La patrimonialisation de leurs caractéristiques géomorphologiques par différents acteurs favorise le développement du géotourisme, une forme de tourisme qui vise à diversifier l'offre d'activités touristiques tout en sensibilisant les visiteurs à la valeur patrimoniale des sites, par la mise en place d'une médiation scientifique. Cet article propose une analyse des offres de médiation de la géomorphologie de la région, évaluées et catégorisées sur la base d'une grille multicritère dans le but d'observer dans quelle mesure elles atteignent ces deux objectifs. Les 33 offres inventoriées ont des caractéristiques très diversifiées, tant sur la forme que sur le fond. La moitié d'entre elles parviennent à démontrer l'intérêt scientifique des sites présentés. La médiation scientifique permet dans ce cas de révéler leur dimension patrimoniale et de dépasser le « masque du pittoresque » qui tend à dissimuler l'intérêt scientifique des sites derrière leurs caractéristiques esthétiques. À l'inverse, dans certains cas, l'activation ressourcielle n'est pas accompagnée d'une prise de conscience patrimoniale, ce qui exclut les offres concernées du champ du géotourisme.

INDEX

Mots-clés: géotourisme, tourisme scientifique, géopatrimoine, médiation scientifique, UNESCO
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