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## SCIENTIFIC RESEARCH AND TOURIST PROMOTION OF GEOMORPHOLOGICAL HERITAGE

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Geotourism has developed rapidly in several European countries. Nevertheless, some supporting materials (panels, leaflets, etc.) are of poor scientific quality and lack method for an efficient diffusion of the scientific concepts towards the so-called «large public». This paper proposes an overview of the four main fields of research where both theoretical and applied studies may contribute to geotourism: (1) the development of methods for the assessment of sites of interest for geotourism; (2) the development of specific symbols and protocols for the simplification of the scientific information on geotouristic maps; (3) the development of methods and techniques that permit the transfer of scientific knowledge to a larger public (scientific mediation); (4) the evaluation of tourists' needs.

**KEY WORDS:** Geotourism, Geoheritage, Geomorphosite assessment, Cartography, Scientific mediation.

### INTRODUCTION

For more than a decade, there has been a major increase of geotourist activities in several European countries, due to the new interest in ecotourism and cultural tourism. Geotourism may be defined as a combination of tourist goods, services and infrastructures developed in a specific area in order to promote its geological and geomorphological heritage in combination with other parts of natural and cultural heritage (archaeology, ecology, history etc.). In some countries, like Switzerland, nearly every village has its educational board, its booklet on the natural beauties of the area or some information about the local geology on the Internet. But, we have to note that not all these materials are of good quality. Sometimes, complex scientific concepts (mass bal-

ance of glaciers, regressive erosion) are not adapted to users with no specific knowledge of Earth sciences. Sometimes, the dynamic dimension of Earth sciences (geodynamics, plate tectonics) is not sufficiently taken into account and the «geoproducts» are limited to incoherent lists of geological elements (landforms, rocks, minerals, fossils). Sometimes, the rocks or landforms are not sufficiently visible in the landscape for people that are not trained in field observation. For all these reasons, geotourism needs specific background research, both at the theoretical and application levels. The objective of this article is to propose an overview of the four main fields of research that may contribute to the improvement of the scientific basis of geotourism products: (1) the assessment of sites of interest for geotourism; (2) the cartographic tools to be developed for the creation of geotourist maps; (3) the methods of scientific mediation aimed at the divulgation of geosciences towards a large public; (4) the evaluation of the tourists' needs. Most of the examples presented here are taken from the results of studies carried out by the members of the International Association of Geomorphologists (IAG) Working Group on Geomorphosites, established in September 2001 during the 5th International Conference on Geomorphology held in Tokyo.

### GEOTOURISM

When defining geotourism, two opposing conceptions emerge. Some scholars (e.g., Stueve & *alii*, 2002) consider geotourism to be synonymous with «geographic tourism», that is a form of tourism aimed at the integrative discovery of an area, with all its natural and human components. In this conception, geology and geomorphology are viewed as the support for the ecological systems and economic development. The second view considers geotourism as a form of tourism aimed specifically at the discovery of the geoheritage of a region (Newsome & Dowling, 2006). These latter authors analyse geotourism as a system made of three subsystems: forms (landscapes, landforms, sediments, rocks, fossils), processes (tectonic activity, volcanic processes, weathering, erosion, deposition), and tourism (attractions, accom-

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modation, tours, activities, interpretation, planning and management). In this way, geotourism is viewed as a type of ecotourism that focuses on geosites. From an economic point of view, geoheritage (geosites) is considered as the basis for tourism development; geosites contribute both to the original (or primary) and the derived (or secondary) tourist offer (Reynard & alii, 2003; Pralong, 2006a) (fig. 1). The original offer is anything that will attract tourists to a place. To take an example, the Roman vestiges and the Pontifical edifices are part of the original offer of Rome. In a context of geotourism, the original offer is mainly constituted by the geoheritage (n° 1 in fig. 1). Examples of sites that constitute the original geotourist offer (n° 2) are the *Fontaine de Vaucluse* in France (archetype of vauclusian springs), the *Uluru* inselberg (*Ayers Rock*) in Central Australia, or the volcanoes of the Aeolian Islands in Southern Italy. The derived offer (n° 3) is composed of the set of infrastructures, goods and services that are proposed to the tourists to facilitate their visit. Cableways for accessing a remote site, interpretative panels or guided tours are elements of the derived offer relating to geotourism (Reynard & alii, 2003; Pralong & Reynard, 2005). The tourist exploitation (n° 4) of the geoheritage may create an impact (n° 5) on the Earth system (Newsome & Dowling, 2006) and involve a degradation of the geoheritage value, as well as situations of risk (n° 6 and 7) that can be created or accentuated by the tourist use of sites where geohazards are particularly intense (e.g., mountains, deserts).

This paper concentrates on the original and the derived geotourist offers. The original offer is constituted of the set of geosites that are present in the study area. The geoheritage can be only one specific object (e.g., an outcrop of dinosaur tracks), but most of the time, it is constituted of a combination of elements of various size, importance and types of geosites (e.g., palaeontological sites, landforms, mineral sites). Some sites of geotouristic interest are of international fame (such as for example, the *Grand Canyon*, the

*Mount Etna* or the *Niagara* waterfalls), whereas most of them are of a more local or regional scope. In this case, one of the main challenges for geoscientists is to develop methods that allow the evaluation and the selection of the most interesting sites, as well as tools that permit the knowledge in regional geology and geomorphology to be diffused to the visitors. These tools constitute one element of the derived offer whose elements may be divided in three principal groups (fig. 2): the infrastructures developed for the accommodation and transportation of tourists; the specific scientific goods (books and other written documents, digital documents, games and souvenirs) that facilitate the comprehension of the geoheritage by the tourists; the scientific services at the disposal of tourists in the area (museums, visitor centres, exhibitions, guided tours, interpretative panels), as well as outside the region (websites). In the following sections, we analyse the contribution of research to the development of the derived offer in four main domains: the assessment and mapping of geosites, the scientific mediation, and the analysis of the needs of tourists. We concentrate on the geomorphological heritage (or geomorphosites, see Panizza, 2001), that is, landforms worthy of protection and/or promotion, especially through the development of geotourism.

## THE ASSESSMENT OF GEOMORPHOSITES

The evaluation of geomorphosites has been developing since the 1990s, in three main domains: within the context of Environmental Impact Assessment (EIA) procedures (Rivas & alii, 1997; Cendrero & Panizza, 1999); for the elaboration of geographic knowledge on the geomorphological heritage in the context of land planning (Stürm, 1994; Grandgirard, 1999); and finally, and more recently, in the context of the promotion of the geomorphological heritage (geotourism, cultural heritage in a broad sense; see Panizza & Piacente, 2003).

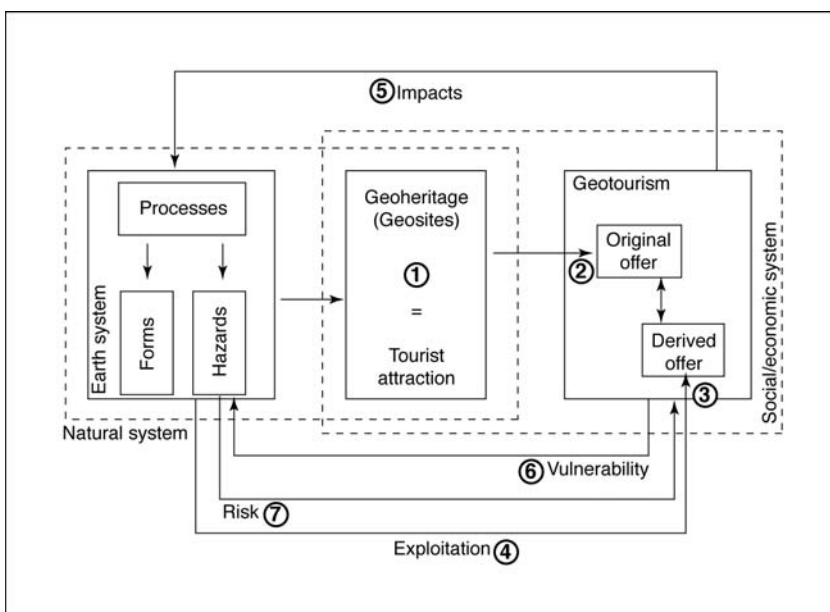


FIG. 1 - Conceptual model of geotourism and its relationships with geoheritage with reference to Cendrero & Panizza (1999) and modified after Reynard & alii (2003) and Pralong & Reynard (2005).

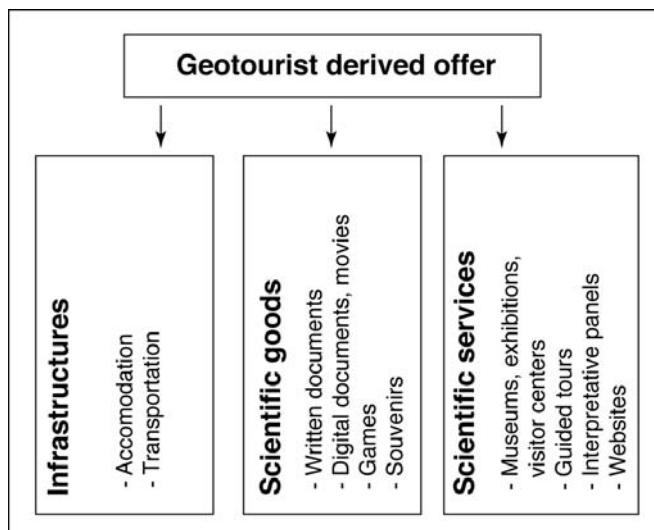


FIG. 2 - Typology of the derived geotourist offer.

The main issue concerning the evaluation of the quality of sites is the objectivity of assessment (Bruschi & Cendrero, 2005). In this context, authors dealing with the assessment of geomorphosites face two main challenges. The first one concerns the definition: which part of the landscape do we consider as sufficiently important to be included in the geomorphological heritage and, more generally, to the cultural heritage of an area? Which criteria do we use to select the important sites with maximum objectivity? Recent studies show that the definition of geomorphosites follows two main approaches (Reynard, 2005): the restrictive one proposes that a landform may be considered as a geomorphosite if (and only if) it contributes to the knowledge and reconstruction of the Earth and climate history, whereas a broader approach considers all the landforms or groups of landforms whose attributes provide them with various kinds of values (ecological, educational, cultural etc.) as geomorphosites. This approach, proposed initially by Panizza and Piacente (1993), is more useful in a tourist context, which attempts to integrate various elements of the natural and human history, within the so-called «integrated cultural landscapes» (Panizza, 2003), whereas the restrictive definition is more adequate in the context of EIA or land planning, where the decision to protect a geomorphological object should be taken only on the basis of scientific criteria, as other (e.g., ecological, aesthetic) values are assessed through other parts of the EIA or the protection of natural assets.

The second challenge concerns the selection of assessment criteria that allow an objective selection of the sites. If it seems useful in a tourist context to consider not only the scientific value of a geomorphological object, but also links with other domains of human and natural history, there is, nevertheless, a risk of confusion due to the multiplication of other attributes, such as the aesthetic, symbolic, religious, ecological, or economic values. This is the reason why we

have proposed a hierarchy of the attributes that allow us to define the quality of a geomorphosite (Reynard, 2005; Reynard & *alii*, 2007): we distinguish a central (scientific) value, and several additional (ecological, aesthetic, economic and cultural) values, that complete the quality of the site and that might be promoted by the tourist sector.

During the last decade, several methods have been proposed for improving the processes involved with the selection of sites deserving protection and/or promotion (see for example the special issues of the journals *Il Quaternario* 18/2005 - Piacente & Coratza, 2005, *Géomorphologie. Relief, processus, environnement* 3/2005 - Reynard & Panizza 2005, and *Geographica Helvetica* 3/2007 - Reynard & Coratza, 2007). It is not the objective of this paper to compare the methods and their respective qualities and defaults. Instead, we propose here a simple classification of the currently existing methods in three groups (for a full description of each method, the reader should consult the original publications directly). A first group evaluates only the scientific quality of the geomorphological landforms. The principal criteria used for the assessment of a landform are its degree of conservation, its representativeness of the regional geomorphology, its rarity, and its contribution to palaeogeographical reconstructions. Additional criteria are the size, age, context and contribution of the landform to Earth science education etc. Examples of methods in this first group, used preferentially within the context of EIA and land-use inventories, are those of Grandgirard (1999), Rivas & *alii* (1997), Bonachea & *alii* (2005) or Coratza & Giusti (2005). A second type of method evaluates not only the scientific quality of the sites, but also their additional values (Reynard & *alii*, 2007). Methods of the third group (e.g., Bruschi & Cendrero, 2005; Serrano & Gonzales-Trueba, 2005; Pralong, 2005; Pereira & *alii*, 2007) not only assess the quality of the sites, but also their use or potential for use. Pralong (2005) has developed a specific method for the evaluation of the tourist quality of geomorphosites and their use by the tourism sector. The importance of the site is evaluated by using four complementary criteria (scientific, aesthetic, cultural and economic importance) and numerical scores based on quantitative indicators (e.g., number of visitors for the economic value, number of mentions of the site in literature for the cultural value) allow the quantitative evaluation of each domain. The second part of the methodology consists of assessing the use of each of the four qualities by the tourist sector. This method has been used in two Alpine tourist regions, Chamonix-Mont-Blanc (France) and Crans-Montana (Switzerland) (Pralong, 2006a) and has revealed whether and how tourist actors consider the importance of the sites of interest for the Earth sciences.

## MAPPING GEOMORPHOSITES

The question of mapping the geomorphological heritage has received much less attention than its evaluation. In the context of tourism, the main issue concerns the preparation of maps useful for tourists when they visit a geomorphosite. Notably in Italy, several scholars have pro-



posed examples of so-called «geotourist maps» (e.g., Castaldini & alii, 2005), which combine geomorphological information and classical tourist information, such as the location of car parks, camping places, cableways etc. With respect to classical «tourist maps», the difference here is the presence of geomorphological data, usually a simplified geomorphological map. More recently, some examples of digital interactive maps dedicated to tourists have been proposed (Boni & alii, 2008).

Nevertheless, the mapping of geomorphosites currently lacks a clear conceptual framework, a specific symbology, and a hierarchy of information to be put on the maps (Bissig, 2008). Carton & alii (2003, 2005) have proposed an initial analysis that distinguishes «maps for specialists» and «maps for non-specialists». The former, more elaborated, very close to classical geomorphological maps, are targeted at specialists of nature conservation and land planners, whereas the target-group of the «maps for non-specialists» is clearly composed of the visitors to the site. The authors differentiate the maps by using a second criterion, i.e. the support for the information (digital maps and paper maps). Recently, Bissig (2008) has proposed a more detailed typology made on the statistical analysis of a set of 51 geotourist maps from eight countries: overview maps, geotourist maps, geoscientific maps (2 types) and interpretative maps.

In conclusion, even if some attempts have been made in order to create maps for geotourists and even if some scholars have proposed some reflections concerning the types of maps and their usefulness to a public of non-specialists in Earth sciences, this field of research is still largely unexplored and will need more attention in the following years.

## THE SCIENTIFIC MEDIATION

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. This is the aim of Earth sciences education, that is, a specific domain of the education in sciences (Astolfi & Develay, 1989), to develop original tools and media for educating people about Earth history (Kramar & Pralong, 2005).

Mediators in Earth sciences face several problems. One is to explain the *dynamic character* of the geology. In fact, for most of the visitors rocks are perceived as particularly solid and stable. Whereas the role of erosion and its dynamic character that is visible through common processes, such as floods, landslides and rockslides, is not too difficult to explain, slow and less visible processes, like weathering or plate tectonic movements, are much more difficult to apprehend.

Another issue is *chronology*. As in astronomy, it is difficult for a non-specialist of Earth sciences to comprehend the long timescale of Earth history and its relationships with the landscape that is currently visible. The challenge for the mediator is to give the visitors tools for reading a landscape from a geological point of view and to discover what Marthaler (2003, 2004) has called the «Earth's mem-

ory», that is, traces from which palaeoenvironments and palaeoclimates can be reconstructed. An additional difficulty, especially in a highly dynamic context, is the fact that the original geological structures are rather discontinuous in the field. The educational products developed in these contexts should, therefore, not only show the dynamic character of geology, but also the spatial and temporal connections between rocks and landforms of different types and ages, and at different scales (Pralong, 2003).

Finally, a recurrent problem is the use of *scientific terms* or a much simpler vocabulary. In fact, chronostratigraphic terms, such as Precambrian, Malm, Oxfordian, Eemian, commonly used within the scientific community, are perfectly opaque for common people and should be avoided when preparing information material for tourists. Moreover, concepts such as «regressive erosion» or «differential erosion», that are also central in geomorphology, are difficult to understand for a non-specialist of Earth sciences. Moreover, some processes are not very intuitive. This is the case of the movement of temperate glaciers, which are divided into two mechanisms: basal sliding (intuitive) and internal deformation of ice (much less intuitive).

In order to mitigate these problems of perception and misunderstanding, several scholars, especially at the University of Lausanne, have developed tools that help to reconstruct the geohistory of a specific area. One is the model of the «Landscape's three histories» (Kramar, 2003, 2005; Pralong, 2003; Marthaler, 2004), that by drastically simplifying the geological history segments the geomorphic history into three main stages: rock formation (sedimentation, petrogenesis), rock deformation (tectonics), and finally, erosion. In the Alps, where these authors have worked, this triple history may be divided further by the main geological divisions of time (Palaeozoic and Mesozoic for the history of rocks, Cenozoic for the tectonic history, and Quaternary for the erosion history). Because of its simplicity, the model has, nevertheless, some limits: erosion is, for example, not limited to the Quaternary and the formation of some rocks, such as the Tertiary sandstones and conglomerates of the Molassic Basin in Switzerland, does not follow the general model (Pralong & Reynard, 2004). Despite these limits, the model has proved to be useful and easy to use both for guiding visitors in the field and for writing booklets and geotourist guides.

Earth sciences education is not limited to the dissemination of knowledge on Earth history for itself. Especially in the context of tourism, it should also show the links that geomorphology has with other parts of the natural and cultural heritage (Panizza, 2003). In fact, landscapes, the main tourist attraction in numerous tourist centres of the world, should not be segmented into monuments, architecture, natural elements etc., but considered in an integrative way (Panizza, 2003; Panizza & Piacente, 2003). Some studies, therefore, show the importance of the relationships between the geological, the biological and the cultural constituents of a landscape. That is, for example, the case for the tourist routes explaining the cultural significance of ophiolites in Emilia-Romagna (Italy) (Bertacchini & alii, 2003a), the comparative description of geo-

morphosites by an Earth scientist and a writer (Bertacchini & alii, 2003b), or the project of Goethe's Georoute from Germany to Italy, through the Alps, that underlines the importance of the German poet for the development of Earth sciences in the 18<sup>th</sup> century (Geyer & alii, 2007).

## THE TOURISTS' NEEDS

The creation of educational material is an important task for geoscientists dealing with geotourism and the use of adapted simplified tools is necessary for explaining geology and geomorphology to tourists. Nevertheless, most of the time, it is not sufficient for obtaining successful results if an analysis of the tourists' needs is not made in parallel. In fact, a «product» (e.g., a panel explaining the morphogenesis of a place) may be adequate for a specific type of tourists (e.g., elderly people), but not for others (e.g., school children). Nonetheless, in numerous Earth sciences education enterprises, this analysis is not made and the knowledge concerning the needs of geotourists is still quite limited among the geoscientific community.

Hose (1994) and Pralong (2006b) have proposed typologies of the public interested in the Earth sciences. The so-called «large public» does not exist; in fact, visitors have quite different profiles: some may possess an excellent knowledge in specific fields of the Earth sciences (e.g., minerals, fossils), others may base their visit on a large integrative cultural interest, whereas the majority of visitors have a very limited or no knowledge in geosciences (Pralong, 2006b). Specific products should be created for these various groups of visitors.

In order to establish the interests of tourists visiting Earth science sites, Pralong (2006a) tested a large panel of persons visiting four places in the Swiss and French Alps (an alluvial zone, an underground karstic lake, a glacier and a gorge). 1634 questionnaires were distributed, from which 469 (28.7%) were returned. Several statistical analyses were made and the principal results show that the visitors like «nature and landscape» holidays, they are expecting explanations, not only on geology and geomorphology, but also on other natural aspects (fauna, flora). Within the different age categories, the elderly people are clearly the group that has the highest interest for Earth sciences.

Another study was carried out in the Swiss Alps in order to better understand the expectations of tourists. Berrebi (2006) and Reynard & Berrebi (2008) analysed four nature trails dealing with geomorphology. The study was divided into two steps: the establishment of the «archaeology of the trail», that is a reconstruction of the various stages and characteristics of the project's implementation, and a test by a group of 20 persons, that made the excursion and answered a questionnaire and a final interview. The questions were especially focused on the educational contents and their form. For this target group, young people, with university formation (but not in geosciences), the expectations were for precise explanations about Earth sciences, visual information (e.g., pictures, figures), and a concentration on specific geoscience topics.

## CONCLUSIONS

This brief overview of the principal contributions of scientific research to the promotion of Earth heritage through geotourism shows that during the last decade several improvements were made in different fields of research. The assessment of geomorphosites, initially developed within the Environmental Impact Assessment (EIA) context and, therefore, clearly oriented toward the protection of the most important and vulnerable sites, has now also moved to the domain of the tourist promotion of the geosites. Thus, the more recent methods not only assess the sites' scientific quality, but also their potential or effective use. Some methods specifically dedicated to the evaluation of the tourist potential of geosites have also been proposed. Nevertheless, the majority of the methods were developed within university projects and are quite complex to use. Most of them are time (and money) consuming and their application is still limited. The development of more simple protocols is urgently required to be able to select the best sites for geotourism and to provide basic knowledge useful for geotourism promoters.

The domain of geosite and geotourist mapping is clearly underdeveloped. Some attempts have been made and several geotourist maps have been published, but a clear conceptual framework and a specific symbology are still lacking. Geomorphosite mapping should not be limited to classical geomorphological mapping and should use the new digital tools (GIS, webpublishing, GPS technologies).

Finally, the domain of Earth science education lacks also a clear conceptual framework. Some proposals have been made, but a larger co-operation with specialists of science education should be improved. Investigations into the expectations of the visitors must also be carried out using specific social science methods (interviews, questionnaires etc.).

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