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SCIENTIFIC RESEARCH ON GEOMORPHOSITES. A REVIEW OF THE ACTIVITIES OF THE IAG WORKING GROUP ON GEOMORPHOSITES OVER THE LAST TWELVE YEARS

ABSTRACT: REYNARD E. & CORATZA P., *Scientific research on geomorphosites. A review of the activities of the IAG working group on geomorphosites over the last twelve years*. (IT ISSN 0391-9838, 2013).

During the last two decades a renewed interest emerged in the scientific community for geoheritage, geoconservation and geotourism research. This was the reason for the International Association of Geomorphologists (IAG) for creating a specific working group (WG) on geomorphosites, that is the geomorphological part of geoheritage, in 2001. This paper reviews the main improvements made in the field of geomorphosite research during the period 2001-2012. A first domain of research concerned conceptual studies, in particular the definition of geomorphosites and the question of their value, as well as the links between geomorphological heritage and geodiversity. Some members of the WG also developed specific methods to assess geomorphosites and proposed guidelines for their mapping and the realisation of geoproducts. The work carried out during the last decade allows us to propose new perspectives, in particular on scale issues, the relationships between geoheritage and geodiversity assessment, the elaboration of guides of practices, and the integration with other disciplines (social and educational sciences, computer sciences, process geomorphology).

KEY WORDS: Geomorphosites, Geomorphological heritage, Assessment, Mapping, Geotourism.

INTRODUCTION

The whole Earth surface is made of landforms; some of them are difficult to detect (*e.g.*, microtopographical forms in lowland areas), others are very spectacular (Migon, 2010) and catch the eye, and some are even recognised by UNESCO as World Heritage Sites for their geomorphological value (Migon, 2009; Panizza, 2009; Badman, 2010). Spectacular landforms (fig. 1) have attracted humans since immemorial times (*e.g.*, Uluru in Central Australia, see Twidale, 2010; the Bandiagara escarpments in Dogon land, Mali, see Le Drezen, 2008; the Machu Pichu Inca sanctuary, Peru, see Vilímek & *alii*, 2007). The initiation of tourism in several parts of the world was influenced by the presence of impressive landforms (glacial landscapes in the Alps; Reynard & *alii*, 2011) and the first national parks in Northern America were created in the 1870s in areas with beautiful mountain landforms (Héritier & Laslaz, 2008).

Since the 1990s, a growing interest for the heritage value of geology and geomorphology has been observed in several parts of the world, in relation to geoconservation (Martini, 1994; Gray, 2004; Burek & Prosser, 2008), geotourism (Dowling & Newsome, 2006), and geopark issues (Zouros, 2004). In this context, during the 5th International Conference on Geomorphology held in Tokyo in 2001, the International Association of Geomorphologists (IAG) decided to create a specific working group (WG) on Geomorphological Sites, with the aim to improve knowledge and scientific research on the definition, assessment, mapping, promotion and conservation of geomorphological heritage. The WG is chaired by the two authors of this paper, experiences have been shared during several workshops and international conferences, and results have been collected in several special publications (tab. 1). Several intensive courses for Master and Ph.D students have also been organised in Bagnes, Switzerland (2006), Lesvos,

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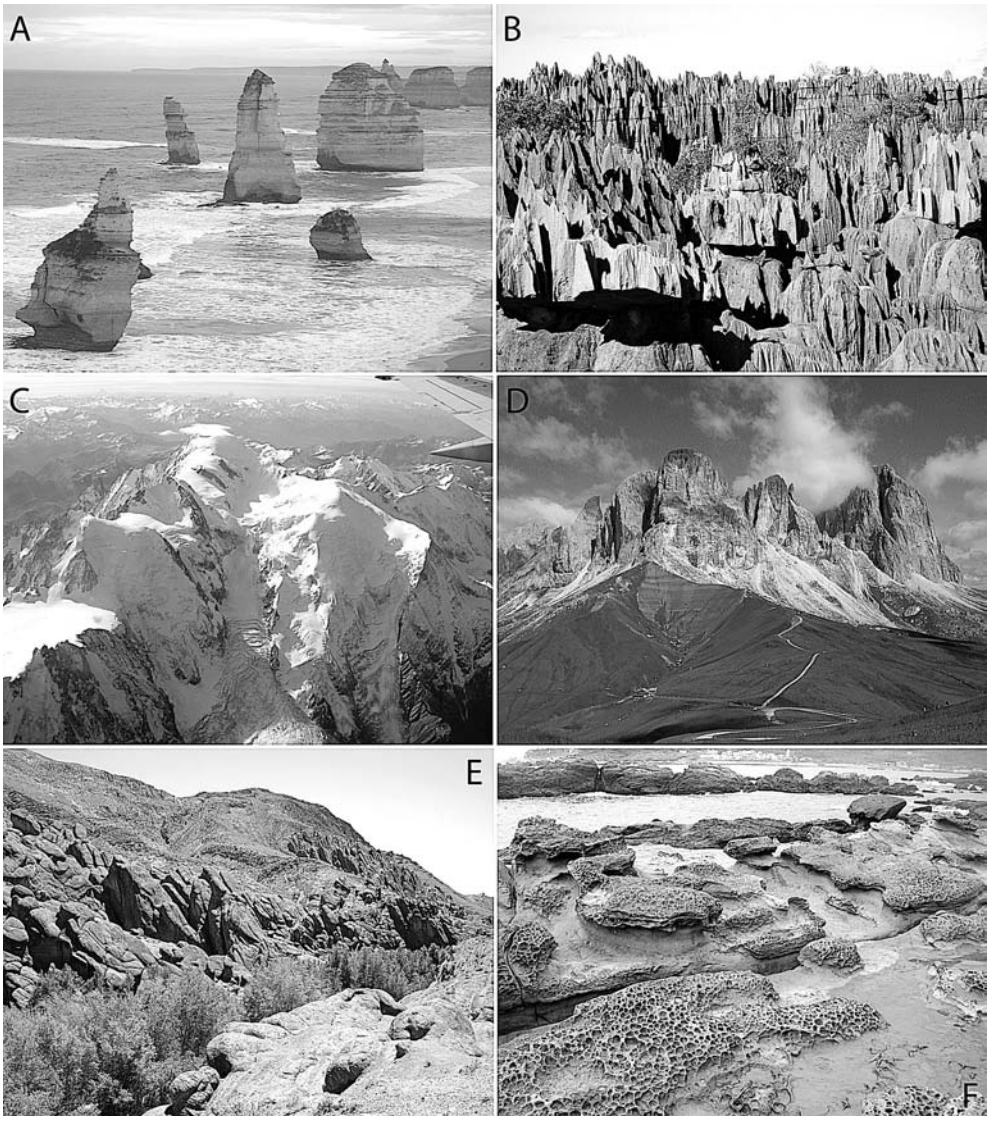

FIG. 1 - Some remarkable geomorphosites around the World. A: The Twelve Apostles (Australia), an active geomorphosite before the collapse of one of the cliffs (photo: B. Joyce). B: The Tsingy of Madagascar classified as World Heritage Site (photo: P. Coratza). C: Glaciers of the Mont-Blanc massif, France/Italy (photo: E. Reynard). D: Isolated structural landform in the Dolomites, Italy, classified as World Heritage Site (photo: E. Reynard). E: Structural and weathering landforms in the Dades valley, Morocco (photo: E. Reynard). F: Coastal weathering landforms at Bitou Cape, Taiwan, situated in a geopark (photo: E. Reynard).

TABLE 1 - Conferences and workshops organised by the working group (WG) on Geomorphosites of the International Association of Geomorphologists (IAG), and the main collective publications edited during the last 12 years

Workshops and Conferences (in brackets main focus)	**Main publications**
Modena, 2002 (assessment); Cagliari, 2003 (assessment, mapping); Mexico-City, 2003, IAG Regional conference (assessment)	Piacente & Coratza (2005) - Geomorphological Sites and Geodiversity, *Il Quaternario*; Reynard & Panizza (2005) - Geomorphosites: definition, assessment and mapping, *Géomorphologie: relief, processus, environnement*.
Florence, 2004, 32nd International Geological Congress (geomorphosites and culture)	Coratza & Panizza (2010) - Geomorphology and Cultural Heritage, *Memorie Descrittive per la Carta Geologica d'Italia*.
Zaragoza, 2005, IAG International Conference (assessment and mapping)	Reynard & Coratza (2007) - Geomorphosites and geodiversity, *Geographica Helvetica.*
Lausanne, 2008 (cartography)	Regolini-Bissig & Reynard (2010) - *Mapping Geoheritage.*
Brasov, 2008, IAG Regional conference (geomorphosites and human heritage)	—
Lesvos, 2007 (geoparks and geotourism); Oslo, 2008 (conservation and management strategies); Paris, 2009 (concepts, assessment, promotion); Melbourne, 2009 (geomorphosites and geotourism)	Giusti (2010) - From geosites to geomorphosites: how to decode the landscape?, *Géomorphologie: relief, processus, environnement*; Giusti (2011) and Reynard & *alii* (2011) - Geomorphosites and geotourism, *Geoheritage*.
Chambéry/Savoie, 2011, International Symposium on Geosite management (geomorphosite management)	A volume of the *Collection EDYTEM* and a special issue of the journal *Geoheritage*, to be published in 2013.

Greece (2007, 2008), Braga, Portugal (2009), Evian, France (2011), and a new edition is planned in 2013 in Lausanne, Switzerland. Several Ph.D theses have been presented in various universities, especially on methodological issues, such as geomorphosite evaluation (Coratza, 2003; Pereira, 2006; Bruschi, 2007), mapping (Regolini, 2012); communication and promotion (Cayla, 2009; Ghiraldi, 2010; Martin, 2012), heritage making (Portal, 2010), and the study of active processes related to geomorphosite management (Bollati, 2011).

This paper proposes a review of the WG activities since 2001, with a focus on definitions and characteristics of geomorphosites, on assessment methodologies, on mapping issues, and on education and dissemination topics.

GEOMORPHOSITES: DEFINITION AND CHARACTERISTICS

As research on geomorphosites is relatively new, the concepts are not completely set and several efforts have been made to define geomorphosites and their main characteristics.

Geomorphosites are a type of geosites (Grandgirard, 1999; Reynard, 2009a). Geosites may be considered as portions of the geosphere that present a particular importance for the comprehension of the Earth's evolution (Reynard, 2004a). They are testimonies of climate and environmental changes, as well as tectonic evolution and the related changes in the history of life at the surface of the Earth, and they allow the reconstruction of palaeoprocesses, palaeoclimates, and palaeoenvironments and the observation of current processes and geological features. For all these reasons, geosites are considered as part of geoheritage, that should be conserved for the future generations, as well as other natural and human heritage places. Cayla (2009) proposed a distinction between *in-situ* and *ex-situ* geoheritage. Geosites (and, therefore, geomorphosites) are *in-situ* geoheritage (visible in the field), whereas mineral or fossil collections stored in museums are part of the *ex-situ* geoheritage. Various terms have been used to qualify the geomorphological heritage, like «geomorphological assets», «geomorphological goods», «geomorphological sites», «geomorphological geotopes» etc. (see Reynard, 2004b, 2009a for a review). Since 2001, the term «geomorphosites» proposed by Panizza (2001) is the most used term, and in 2005 the WG on Geomorphological Sites was renamed as the WG on Geomorphosites.

Both geosites and geomorphosites, as part of geoheritage, have to be considered as the result of human valuation. In reality, if they are considered as heritage, it is because society, especially geoscientists, but also conservationists or people in the tourist sector, give them a value. Therefore, the issue of the value of geomorphosites has been much debated between the members of the WG because it is from this concept that the various methods for the evaluation of geomorphosites have been developed. First of all, two main approaches have been developed for defining what geomorphosites are (Reynard, 2004a): a restrictive one and a broader one. According to the restrictive definition, geomorphosites are considered as landforms that present a particular interest for the comprehension of the Earth and climate history (Grandgirard 1999). Their evaluation should, therefore, be based essentially on criteria characterising their scientific quality (rarity, exemplarity for the Earth Sciences, etc.). Other authors (Panizza & Piacente, 1993; Panizza, 2001; Panizza & Piacente, 2003) proposed a broader definition, considering geomorphosites as landforms that present a certain value due to human perception or exploitation. These authors distinguished four types of values: scientific, aesthetic, cultural/historical, and economic. Successively, Reynard (2004b, 2005) and Reynard & *alii* (2007) proposed to distinguish two levels of value: the central (scientific) and additional values (ecological, aesthetic, cultural and economic). Serrano & Gonzalez-Trueba (2005) divided the value of geomorphosites into three categories: the scientific (or intrinsic) value, added or cultural values, including aesthetics, cultural elements, education, etc., and a so-called use and management value based on the evaluation of the accessibility, fragility, vulnerability, intensity of use, risk of degradation, state of conservation, impacts, quality of view, and limits of acceptable change. The approach by Pereira & *alii* (2007) divided the value of geomorphosites into four parts: the scientific value, three additional values (cultural, aesthetic and ecological value), use values (based on criteria such as accessibility, visibility, present use of geomorphological interest, present use of other natural and cultural interests, legal protection, and equipment and support services), and finally the protection value, related to the integrity and vulnerability of the site. Finally, Giusti & Calvet (2010) suggested the distinction between the central (scientific) and additional values. As scientific values, they considered not only the value related to the quality of the site (that is its interest for the knowledge of the Earth history), but also the value derived from the history and epistemology of geomorphology (that is the interest of a site for the geomorphology as science). They divided the additional values into two groups: the cultural values, including the aesthetics, the cultural identity, and the historical, political and religious interest, and the so-called societal values, that is the ecological, economical, educational, epistemological and social interest for the society. This short review shows that the conceptualisation related to geomorphosites is still under construction. Nevertheless, three groups of values can be highlighted: the scientific value (that is the interest of sites for Earth history and for the history and epistemology of geomorphology), several additional values (aesthetic, ecological, and cultural in a broad sense), and use and management values, that can be divided in three sub-groups (educational value, economic value, including the tourist value, and protection; tab. 2). The scientific and additional values can be considered as intrinsic values, whereas the management and use values are to be related to the societal values in the sense of Giusti & Calvet (2010).

In comparison to other geosites, three main characteristics may be considered as specific to geomorphosites

TABLE 2 - Values assessed and main criteria used by several assessment methods. Giusti & Calvet (2010) did not propose a method but much more a conceptual analysis of various values (grey cells indicate that the criteria were not discussed)

Values and criteria	Coratza & Giusti (2005)	Bruschi & Cendrero (2005)	Serrano & Gonzalez-Trueba (2005)	Reynard & *alii* (2007)	Pereira & *alii* (2007)	Giusti & Calvet (2010)
Scientific value	X	X	X	X	X	X
- interest for scientific research	X	X	X	X	X	X
- interest for epistemology of geomorphology						X
- rareness	X	X		X	X	
- representativeness, exemplarity	X	X	X	X	X	
- integrity	X	X	X	X	X	
- diversity of elements		X	X		X	
- association with other heritage sites	X	X			X	
- age, chronology, palaeogeographical value		X	X	X		
- morphotypes (genesis)			X			
- dynamic			X			
Distinction scientific value / additional values			X	X	X	X
Distinction scientific value / use values		X	X		X	
- ecological value assessed	X			X	X	
- cultural value assessed	X		X	X	X	
- economical value assessed	X			X		
- conditions of visit assessed (access, visibility)		X	X		X	
- state of protection assessed	X	X			X	
- educational value assessed	X		X			
- area, extent	X	X				
Distinction intrinsic value / societal values						X

(Reynard, 2004b; 2009a): the aesthetic dimension, the dynamic dimension and the imbrication of scales. Many geomorphosites often have a central aesthetic character. This is the reason why in several public policies on nature conservation, geomorphosites are qualified as «natural monuments» and why geomorphosites, especially the large ones, are often considered as landscapes (Reynard, 2005; 2009c). The second recurrent dimension is the dynamic one. Geomorphosites are the type of geosites that best allow the observation of current Earth dynamics and processes. The main issues in terms of geoheritage management related to active landforms are the auto-destruction by the process activity (Bollati, 2011) and the impacts of the active landforms on human activities. In the latter case, protection measures, that often aim at reducing the process intensity, may oppose geoheritage management, that should, on the other hand, tend to conserve the dynamic activity of the landform (Smith, 2005; Smith & *alii*, 2009; 2011). The scale dimension has not been fully addressed at the moment. The challenge of scale in geomorphosite studies is the fact that landforms range from the microforms (some centimetres) to large landscapes. Also the complexity ranges from single and relatively simple landforms (due to one process) to complex geomorphological systems where several processes interact. This question is particularly challenging in the selection (Rodrigues & Fonseca, 2010) and mapping (Carton & *alii*, 2005) processes.

The relationship between geomorphosites and geodiversity is the last conceptual issue that occupied the WG. It is not the aim of this paper to discuss the concept of geodiversity (for a review, see for example Gray, 2004; Zwolinski, 2004; Serrano & Ruiz-Flaño, 2007; Panizza & Piacente, 2009; Serrano & Ruiz-Flaño, 2009). It is just to be noted the great difference between the two concepts: geomorphosites (and geoheritage in general) are a selection of points of interest depending on the valuation given by scientists (or the society in general) at a given time, whereas geodiversity is intrinsic to nature, and depends on the range of various geoscientific elements (geological structures, landforms, soils, hydrological features). Geodiversity and geoheritage interact but are not synonymous.

ASSESSMENT

The growing interest in environmental management has increased the demand for adequate tools to assess, conserve and manage natural assets, including the geomorphological ones. Hence, the need to provide accurate criteria to assess the landforms that deserve being identified, known, safeguarded and promoted. In these circumstances, it is of paramount importance to define priorities and a scale of values in order to make choices and to define decision strategies.

In literature, numerous methods are described for the quantitative assessment of landforms. The earliest go back to the 1970s and were generally developed by scholars from English-speaking countries, in particular from the United States of America. Some of these propose morphometric measurement methods of diverse landscape compo-

nents, which are considered representative of the scenic quality of a landscape. Others are more subjective and concern the perception of an entire landscape in quantitative terms (Panizza & Piacente, 2003). Nevertheless, the limits of these assessment procedures are considerable, because they are either too subjective or based on an unnatural subdivision of geomorphological assets.

In the last few years, several methods, based on the measurement of specific features of geomorphosites, have been increasingly applied. A problem found in almost all of them is the subjectivity of assessment and, consequently, the difficulty for one operator to replicate results obtained by another (Bruschi & *alii*, 2011). In fact, the scientific quality of an asset is a purely indicative numerical value, which can be subject to variations determined by the «aim» (inventories, environmental impact assessment, tourism promotion and popularisation), the «working scale» (international, national, regional and local) and the «type of methodology adopted» (direct and indirect or parametric methods; see Bruschi & Cendrero, 2009). In general, all methodologies inevitably imply a degree of subjectivity since the intrinsic value of these environmental elements cannot really be measured.

Concerning the objective of the evaluation, several attempts have been made to assess the quality of geomorphological heritage, mainly in three domains: within the context of environmental impact assessment (Bonachea & *alii*, 1995; Barba & *alii*, 1997; Rivas & *alii*, 1997; Bruschi & Cendrero, 2005; Coratza & Giusti, 2005) and land planning (Stürm, 1994; Grandigirard, 1999); for inventories of natural heritage sites (Serrano & Gonzales Trueba, 2005; Reynard & *alii*, 2007); and finally, and more recently, in the context of tourist promotion (Pralong, 2005; Pralong & Reynard, 2005) and management of nature parks (Pereira & *alii*, 2007; Zouros, 2007).

Working scale is an extremely important point in the evaluation procedure as well as in many other geomorphosite research fields (inventory, mapping, etc.), which influence the viewpoint of the operator: the results obtained from studies conducted at different scales are not interchangeable (Grandgirard, 1999).

Regarding the ranking methods used for geomorphosites, two main types or categories can be recognised: direct methods, where sites are valued through the synoptic assessment by individual experts or groups of experts and indirect or parametric methods, where a series of characteristics or «parameters» are used for the description of sites and evaluated separately, normally through the use of numerical ranks (see Bruschi & *alii*, 2011, and reference therein).

The development of assessment methods was one of the main objectives of the WG. The original objective of the WG was, after four years, to publish guidelines to assess geomorphological sites. Nevertheless, the works have shown that the development of general guidelines to be used by all the countries was quite impossible; the choice of assessment methods depends indeed drastically on the objectives and the context of the research. For this reason, the project of guidelines was abandoned and several of the methods available were documented, taking into account particularly those developed by members of the WG (*e.g.*, Coratza & Giusti, 2005; Bruschi & Cendrero, 2005; Serrano & Gonzalez Trueba, 2005, Reynard & *alii*, 2007; Pereira & *alii*, 2007; Bruschi & *alii*, 2011; Feuillet & Sourp, 2011; Coratza & *alii*, 2012). It is difficult to extract a common approach worth using in various contexts and countries. Nevertheless, it is possible to recognise common and recurrent assessment criteria, like rarity, representativeness and integrity, and others, for example ecological value, palaeogeographic importance, educational value etc., that are dependent on the context of the assessment and on the aims of the research (Reynard & *alii*, 2007). Of course, other methods, developed for example at the national level and concerning all kind of geosites exist.

MAPPING

Compared with research carried out in the field of geomorphosite identification (Wimbledon & *alii*, 1995; Panizza, 2001), classification (Marchetti, 1999, and reference therein), and assessment (Reynard 2009b, and reference therein), geomorphosite mapping has not received the same consideration in the past. A considerable impulse to investigations on this topic was recently given by the works of several authors especially in Europe (Carton & *alii*, 2005; Castaldini & *alii*, 2005 a and b; Bertacchini & *alii*, 2007; Bissig, 2008; Orrù & Panizza, 2009; Rovere & *alii*, 2010; Regolini, 2012), where some methods for the cartographic representation of geomorphosites, especially in the field of Earth Heritage promotion, are illustrated.

The criteria commonly used for geomorphosite mapping and, more in general, geosite mapping so far, have not seriously faced the problem of how these sites can be represented in an immediate and easily understandable form. Therefore, mapping landforms and processes could help spread awareness of geoconservation among the general public. Nevertheless, designing maps is not a simple procedure and in the codification phase (implementation of the map) several points should be considered (Joly, 1997; Coratza & Regolini-Bissig, 2009), in particular when mapping geomorphosites efforts should be made to identify and use symbols corresponding to the following semiotic criteria (Bertin, 1967): communicative immediacy, graphic originality and flexibility (Martin, 2012; Regolini, 2012).

Generally, although it is not possible to set up a standardised methodology valid for all purposes, considering also the diversity of the geological and geomorphological features of the landscape, it is nevertheless possible to identify a methodological procedure for map implementation. The WG worked in this direction, identifying guiding principles for geomorphosite mapping (Coratza & Regolini-Bissig, 2009, Regolini-Bissig, 2010; Regolini, 2012), and it organised a specific workshop on these issues in 2008 in Lausanne (Regolini-Bissig & Reynard, 2010). As

pinpointed by Coratza & Regolini-Bissig (2009), the approach for elaborating a map of geomorphosites can be considerably different according to both the «aim» (census with scientific purposes, appraisal and promotion of geological heritage, conservation, etc.), the «working scale» (international, national, regional, local) or the «final users of the map» (tourists, students, consultants, etc.). Concerning the aim's issue, maps are produced and serve different purposes such as the assessment, conservation, management or promotion of geomorphosites. Each application requires its own mapping principles in order to fulfil the specific needs. Scale is an extremely important point in mapping. From the cartographer's point of view, a number of signs must be depicted in the limited space of a map, using symbols able to adequately describe the portion of territory represented at that particular scale (Bertin, 1967). Indeed, the scale of the maps depends on the area to be covered and the way in which the geomorphosites are to be visualised: point symbols, pictorial or pictograph symbols, and classical geoscience mapping symbols. Last but not least, when producing maps particular attention should be given to the intended audience (Regolini, 2012): maps should not be designed in the same way whether they are produced for scientists, planners, students or tourists. Different map user groups have different requirements and map reading skills: a good map for specialists is not necessarily a good map for non-specialists (Carton & *alii*, 2005). Defining the intended audience helps to focus the mapping efforts and to produce tangible maps.

Mapping may also depend on many other factors such as the financial resources, which determines characteristics of the map such as mapping techniques and print options, scientific competences and technical means, which determine the choice of the maps' form and size (paper or digital maps, material, and size of the map; Coratza & Regolini-Bissig, 2009; Regolini-Bissig, 2010; Regolini, 2012).

In the framework of the IAG WG, numerous examples of maps directed to a public of non-specialists in the field of Earth heritage promotion (geotourism) can be recognised. Particularly active in this research field were the Italian and the Swiss scholars. Castaldini & *alii* (2005a) proposed a methodological approach for the implementation of geotourist maps based on the principle of simplification. These maps (*e.g.*, Castaldini & *alii*, 2005b; Bertacchini & *alii*, 2007) combine the most evident geological-geomorphological aspects with fundamental tourism information and emphasise only the landscape elements that the tourist can directly recognise and observe by himself. Other researchers have studied the geomorphological risk in tourist areas (Piccazzo & *alii*, 2007). In this context, a methodology for the assessment and the cartography of geomorphological hazards and vulnerability of visitors along tourist trails (Coratza & *alii*, 2008; Pelfini & *alii*, 2009) has been proposed. The Swiss scholars have focused their research on the task of designing interpretative maps and other communication material (such as websites), analysing both the final users (their knowledge of geomorphology, their perception of geomorphological processes and landforms, and more in general of geomorphological landscapes) and the implementation of the map (which visualisation, topographic background, scale, symbols, etc.) in order to better understand the effectiveness of the interpretation of the map (Bissig, 2008; Reynard & Berrebi, 2008; Martin & Reynard, 2009; Regolini-Bissig & *alii*, 2009; Regolini-Bissig, 2010; Martin, 2012; Regolini, 2012).

The fast technological advancement of digital electronics and the consequent availability on the market of more and more powerful and affordable computers have favoured, also in the field of popularisation and mapping appraisal of geomorphosites, the ever increasing use of electronic instruments and devices. The WG has, therefore, dedicated a specific intensive course on the theme «*Using numerical technologies for the assessment and the promotion of geosites*» in Evian (France) from 5th to 7th September 2010. Examples of this are offered by the web publication of geological-geomorphological itineraries and geotourist maps (Gregori & Melelli, 2005; Barbieri & *alii*, 2008; Coratza & *alii*, 2008; Ghiraldi & *alii*, 2009; Martin & Reynard, 2009; Martin, 2010, 2012).

EDUCATION AND DISSEMINATION

In modern societies, environmental problems of a most pressing and urgent nature have arisen, but Earth Sciences still occupy only a marginal role. This is difficult to justify, considering the importance of Earth processes in the history and development of life and civilisation. Experience shows that the population's knowledge of geomorphological processes and landforms is relatively poor. In most countries, geomorphology is not part of the *curriculum* in compulsory schools. Moreover, the transmission of geomorphological information by the media is very often vague, even distorted. It is therefore necessary to find new paths and communication strategies, which may fill this gap. Moreover, the ever-growing consolidation of a new kind of tourism, more sensitive to environmental issues, has given rise to rapid expansion of the «geotourism», a niche of Nature tourism that has developed worldwide in the last years, in which the main objects are geosites and geomorphosites. Furthermore, with cultural aspects, civilisation's heritage elements and leisure infrastructures, natural elements are among the main factors for the attraction of tourist sites. Notwithstanding this, geomorphology is rarely considered as major tourist material.

The IAG WG felt, during these years, the need to increase the visibility and sensitivity of geomorphology not only in the scientific world and institutions but also in society in general and to widespread awareness of geomorphology as a key factor of tourist attraction. Several examples of geotourism products, excursion and educational footpaths with panels, equipped trails, geotourism and tourism-environmental maps, books in hard copy and digital format, videos, virtual flights, multimedia and audio CDs, etc., have been elaborated by members of the WG in the last decade in several European countries. Very often,

these geoproducts provide interpretation of local geological and geomorphological landscapes and landmarks (Dowling & Newsome, 2006; McKeever & *alii*, 2006; Hose, 2008; Neto de Carvalho & Rodriguez, 2009; Dowling & Newsome, 2010; Gordon, 2012), based on a pedagogic approach (*e.g.*, Pralong, 2003; Marthaler, 2004; Sellier, 2009, 2010), and generally communicate with those who already have some awareness of geology (Gordon, 2012).

Several authors have developed projects of geological (*s.l.*) education for a wide audience with the creation and installation of on-site information panels (see Mansur & Soares da Silva, 2010; Miccadei & *alii*, 2011; Cardozo Moreira, 2012) and geological trails (see Garavaglia & Pelfini, 2011; Wrede & Mügge-Bartolović, 2012), the realisation of geotourist maps (see Castaldini & *alii*, 2005b; Faccini & *alii*, 2008; Scalella & *alii*, 2008; Faccini & *alii*, 2012), and the planning of geological excursions (see Piacentini & *alii*, 2011). The common aim of this kind of activities is to increase the awareness and the sensitivity of young people to Earth Sciences (Piacentini & *alii*, 2011).

Other research has highlighted the close relationship between geoheritage and other natural and cultural heritage. The aim was to attract a wider public with little or no apparent interest in geology *per se* by developing an integrated-type tourism proposal. It was, for example, the case for the tourist route linking the features of the physical environment, the anthropogenic aspects and the cultural significance characterising the ophiolitic ridges in Emilia-Romagna, Italy (Bertacchini & *alii*, 2003a); the geological-literary itinerary developed by considering how natural landscapes and their geological and geomorphological features have inspired literature, poetry, art and music (Bertacchini & *alii*, 2003b; Gordon, 2012); the project of Goethe's journey in Italy, where the journey undertaken by the great German writer by coach or boat from the Alps to Sicily over 220 years ago was re-examined and a comparison between his geographical and geological observations and the most advanced theories of Earth Sciences was made (Geyer & *alii*, 2007; Panizza & Coratza, 2012).

The analysis of geoproducts produced till now has highlighted the nearly total lack of a clear and rigorous methodological approach in drawing up these essays. Of course the elaboration of this kind of products and facilities is not a simple procedure and depends on many factors. Martin & *alii* (2010) proposed a methodological approach based on three steps and highlighting the necessity to clearly define four main domains, the target public, the site, the content/theme and the medium, before the fulfilment of the product. A shared philosophy as proposed in Martin & *alii* (2010) with the described methodological approach for the implementation of geoproducts represents a first step. Therefore, the next challenges for the international community of geomorphologists, and more generally geologists, include the establishment of working guidelines and principles for the development of effective geoproducts. To do this, the improvement of a larger co-operation with specialists of educational sciences is fundamental.

CONCLUSIONS AND PERSPECTIVES

This paper has proposed an overview of the activities of the members of the WG on Geomorphosites of the International Association of Geomorphologists (IAG) over the last twelve years. Several improvements have been made in the conceptualisation of this new field of research, and in several sub-areas such as assessment methods, mapping issues, and educational issues. Results have been collected in several issues of international journals (tab. 1) and in a book dedicated particularly to Master and Ph.D students working on geomorphosite issues (Reynard & *alii*, 2009). Of course, it was not possible to refer in this paper to all the works published until now, in particular case studies and specific realisations. We have focused on the main improvements, in particular: (i) the efforts made for a better definition and conceptualisation of geomorphosites; (ii) the challenges related to the selection and evaluation of geomorphosites, in particular the issue of reducing subjectivity; (iii) the proposal of guidelines for geomorphosite mapping, in particular in the geotourism sector; (iv) the issue of interpretation of geomorphological heritage, in particular the sensitive question of the adequacy of geoproducts with the public needs and previous knowledge.

Nevertheless, several questions have not been solved until now, and several issues should be addressed in the future:

(i) The scale issue in geomorphosite studies is not clearly addressed, even if it impacts on several domains such as the assessment and cartography of geomorphological heritage; in particular, more research is needed on the means to integrate micro-landforms in geomorphosite selection that has been restricted until now to medium to large landforms and landscapes;

(ii) Relationships between geoheritage assessment and geodiversity assessment may also be explored in the future, especially in terms of geoconservation. In other words, should geoconservation, and in particular the selection of sites worth being protected for future generations, be derived from geodiversity evaluation or from geosite selection?

(iii) The original objective of the WG, that is the elaboration of a common methodology for the assessment of geomorphosites, could not be reached mainly because of geographical and societal particularities. Nevertheless, guidelines such as those proposed by Coratza & Regolini-Bissig (2009) for the mapping issues, or those proposed by Martin & *alii* (2010) for the elaboration of geotourist products, are particularly useful and a book of good practices in the fields of geomorphological heritage assessment, cartography and interpretation should be encouraged;

(iv) The integration of geomorphosite studies with other scientific domains is needed, in particular with educational and social sciences in the field of public characterisation, with computer sciences in the field of knowledge dissemination using digital technologies, with political and law sciences in the field of geoconservation, and with process geomorphology in the management of geomorphosites, in particular dynamic environments.

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