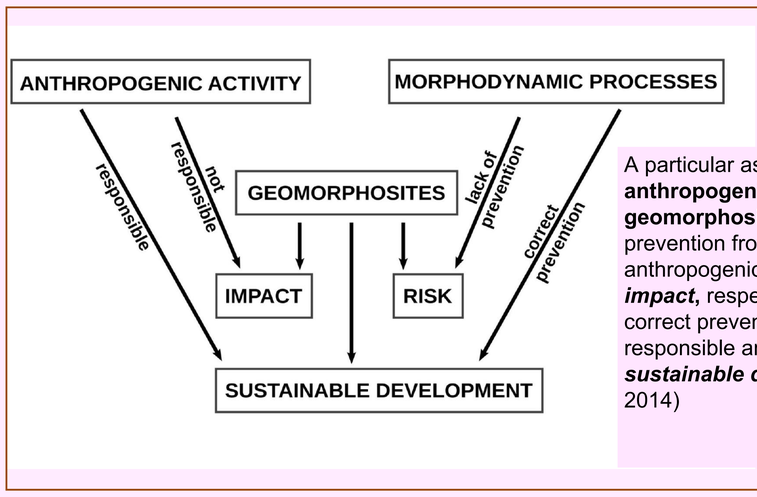
A comprehensive assessment of geomorphosites in relation to both natural hazards and tourist fruition and activities

Irene Bollati[1], Pierluigi Brandolini[2], Alberto Carton[3], Paola Coratza[4], Marco Giardino[5], Giovanni Leonelli[1], Mario Panizza[4], Valeria Panizza[6], Manuela Pelfini[1], Luigi Perotti[5], Sandra Piacente[4]

[1]Dipartimento di Scienze della Terra "A. Desio", Università degli Studi di Milano
[2]Dipartimento di Scienze della Terra, dell'Ambiente e della Vita, Università degli Studi di Genova
[3]Dipartimento di Geoscienze, Università degli Studi di Padova
[4]Dipartimento di Scienze Chimiche e Geologiche, Università degli Studi di Modena e Reggio Emilia
[5]NatRisk Research Centre and Dipartimento di Scienze della Terra, Università degli Studi di Torino
[6]Dipartimento di Storia, Scienze dell'Uomo e della Formazione, Università degli Studi di Sassari (valeria@uniss.it)

ABSTRACT
In the framework of the relationships between geomorphological heritage and natural hazards, the studies carried on by the members of the AIGeo Working Group on "Geomorphosites and cultural landscape", focuses mainly on monitoring evolution rates of active geomorphosites in different morphoclimatic contexts, in order to evaluate risk scenarios in the context of tourism, and on the analysis of climate trends and quantification of rates of climate-related processes in areas of scientific and landscape interest. These lines of research are fundamental for forecasting evolutionary scenarios, especially regarding hazards and impacts on natural and cultural assets. There has been a growing interest in the mutability of geomorphological heritage (e.g. geomorphosites), as a consequence of both natural-climate and human pressure. Recent research has allowed inventories to be made for evaluating and analysing geomorphosites not only in term of their geoheritage value but also for providing information on geohazards related to the intensity and frequency variation of climate-related superficial processes.
Within the framework of a comprehensive assessment of geomorphosites in relation both to natural morphodynamics and tourist fruition and activities,

some main lines of research are developed



A particular aspect concerns the relationships between **anthropogenic activity**, **morphodynamic processes** and **geomorphosites**. The table pinpoints how the lack of prevention from morphodynamic processes or not responsible anthropogenic activity, may cause situations of ***risk*** or ***impact***, respectively, for geomorphosites. On the contrary, correct prevention from morphodynamic processes and responsible anthropogenic activity, favour a policy of ***sustainable development***. (Panizza M. and Piacente S., 2014)

MAPPING GEOMORPHOLOGICAL HAZARDS IN RELATION TO GEOTOURISM AND HIKING TRAILS IN COASTAL AREAS

The activity of geotourism necessarily involves the interaction with the natural environment, and the degree of contact will vary depending on the geotourists' cultural background and physical ability. In this sense, there are increasing requests to exploit a territory by creating suitable networks of trails. It is, therefore, necessary to survey the potential hazards and the geomorphological features that could impede progress along tourist itineraries in order to allow tourists to enjoy the landscape (geosites) and avoid potential harm. The knowledge of the natural environment represents the first step in the risk mitigation (Brandolini et al. 2006; Brandolini, Pelfini, 2010).

Example of geotourist map of Palmaria (after Brandolini et al., 2009)

Trail sectors in the western side of Palmaria Island affected by geomorphological hazards due to running water and rock fall processes (photo by P. Brandolini.

Types of geosites	Tourist vulnerability (hiking path features)
1. Geomine	8. Slippery or rambling track;
2. Karst	9. Narrow trail
3. Geomorphological	10. Exposed path
4. Geological	11. Track steepness – a. low; b. medium; c. high
Geomorphological hazards	**Other geotourist emergences**
5. Rock fall	12. Beach;
6. Debris flow (associated with heavy rainfall)	13 Geo-panoramic point
7. Sea storm	14. Military structures

A typical case study representative of a tourist area in a coastal environment is Palmaria Island in the Liguria region (Northwestern Italy). With a land area of 1.65 km2 and a maximum elevation of about 190 m a.s.l., it is a very small island, which is inscribed in the UNESCO World heritage list. It is a site of great geomorphological and cultural value, characterised in particular by the presence of historic quarrying traces of Portoro marble – a grey-black limestone with yellow veins – dated back to Roman times (Brandolini et al., 2009).

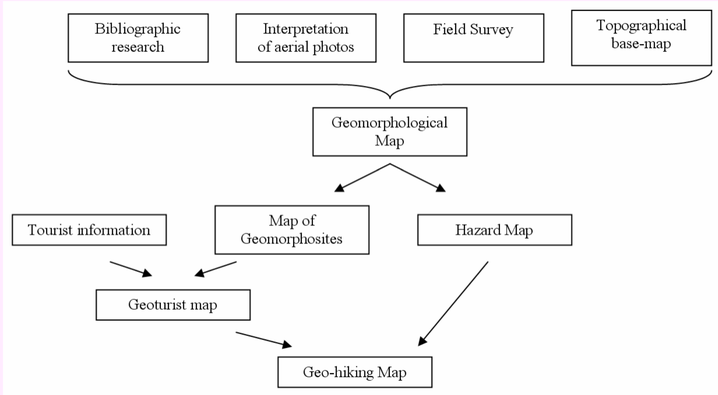
Studies concerning interconnections between geomorphology and tourism, in areas where natural processes and untouched environment are prevailing, have been carried on. As is often the case with leisure sports activities, like mountain climbing, free climbing and rafting, the geomorphological resource is often the main motivation for destination choice. It is therefore advisable to not ignore the possible risks linked to the dynamic nature of the environment in which these activities take place. Researches on assessment of the natural risk for "extreme" sports like climbing or canyoning have been carried on, concerning the assessment of dynamic processes, geotechnical conditions, and so on and the collection of scientific information and data, concerning the active geomorphological processes, in special database or cards, available to the public (Panizza V. e Manca, 2006; Motta et al., 2009)

Descent along the canyon of Sa Spendula (South western Sardinia)

Active geomorphological processes	River processes	River processes
	▪ trend of river flows in relation with rainfalls ▪ morphological characteristics of the river bed (deepness, width, high of falls ecc.) ▪ seasonal variability in the flows and bed characteristics Slopes processes ▪ unstable boulders ▪ falling of debris from the top and frequency of the phenomenon	▪ seasonal flows measures and current velocity ▪ measures of the river erosion ▪ stability of river slopes ▪ ecc. Slopes processes ▪

Examples of data and information to be collected by researchers or climbing and canyoning trainers, useful to assess the risks connected with the active geomorphological environment.

The workflow that leads to the creation of a geo-hiking map, which emphasises only the landscape elements that the tourist can recognise and observe, as well as the possible hazards, is composed by different step and is shown in figure (Coratza et al., 2008).



The geo-hiking map derives from the combination between the geo-tourist map and the geomorphological-hazard map: the first one is a map of geomorphosites enriched with useful indication for tourists (signed paths, refugees, camps etc.); the second one shows hazard levels of different landslide types, snow avalanches and floods.

INVESTIGATIONS ON ACTIVE GEOMORPHOSITES

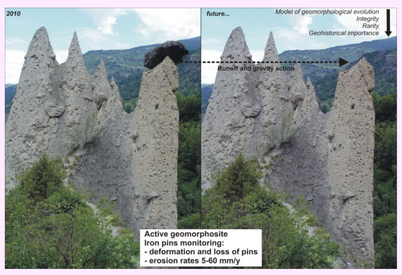
• ***Active geo(morpho)sites*** (sensu Reynard, 2004) are those sites of geomorphological interest subject to natural dynamic and climate-related processes that are able to induce changes in terms of ***GLOBAL VALUE*** and ***HAZARDS*** and ***IMPACTS*** in different morphoclimatic contexts

Calanchi landscape at Monte Oliveto Maggiore, Crete d'Arbia, Toscana. Shaly outcrops in Appeninic context under intense water runoff give origin to badlands in Mediterranean climate. (photo by I. Bollati, 2009)

Pyramides d'Euseigne (Canton Valais, Switzerland). Heterogeneous glacial deposits under intense water runoff give origin to earht pillars in Alpine climate. (photo by I. Bollati, 2012)

THE PROBLEM OF DEALING WITH ACTIVE GEOMORPHOSITES IS TWOFOLD

a) changes in geomorphological processes may directly influence the value of sites of geomorphological interest



Pyramides d'Euseigne (Canton Valais, Switzerland). In this case the intensifying of runoff process and the consequent fall of top block that act as protection and allow the formation of pyramids, induced for example by climate variations, may provoke loss of features impacting on attributes of site as geomorphosite. (Figure from Pelfini & Bollati, 2014)

b) active geomorphological processes may represent natural hazards and be a source of risk where tourist trails and activities are present

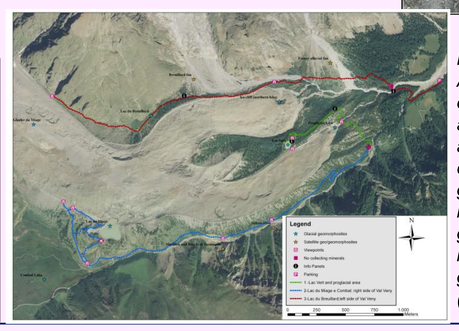
Miage Lake (Val Veny, Aosta Valley, Italy). In 1996 the detachment of ice blocks from the ice cliff provoked a wave that submerged tourists located too close to the lake, on the lake shores. (photo by I. Bollati, 2011)

MONITORING EVOLUTION RATES OF ACTIVE GEOMORPHOSITES IN DIFFERENT MORPHOCLIMATIC CONTEXTS (REYNARD ET AL. 2007) IT IS FUNDAMENTAL FOR FORECASTING EVOLUTIONARY SCENARIOS, ESPECIALLY REGARDING HAZARDS AND IMPACTS ON NATURAL AND CULTURAL ASSETS

Pyramides d'Euseigne (Canton Valais, Switzerland). Example of monitoring of runoff intensity through iron pins and analysis of fixed reference points. The drainage duct has been filled in completely in two years (2010-2012; photo by I. Bollati)

Pyramides d'Euseigne (Canton Valais, Switzerland). Example of measuring of erosion rates thourgh exposure of roots of trees (photo by I. Bollati, 2010)

EDUCATIONAL EXEMPLARITY AND *ACCESSIBILITY* OF ACTIVE GEOMORPHOSITES WILL ALLOW THE RESEARCH RESULTS TO BE DISSEMINATED TO THE GENERAL PUBLIC, BY ENRICHING EXISTING TOURISTIC TRAILS THROUGH MAPPING AND DESCRIBING POSSIBLE HAZARDS DERIVING FROM ACTIVE GEOMORPHOLOGICAL PROCESSES IN THE SURROUNDING AREAS (PELFINI ET AL., 2009)



Miage Glacier (Val Veny, Aosta Valley, Italy). The existing touristic trails. that allow to explore the different areas of the glacier, are characterized by active geomorphosites and represent a complex geomorphosite where illustrate concepts of geomorphological hazard (Bollati et al., 2013).

REFERENCES: BOLLATI I.; SMIRAGLIA C., PELFINI M. (2013) – Assessment and selection of geomorphosites and trails in the Miage Glacier Area (Western Italian Alps9. Envrionmental Management, 51: 951-967.; BRANDOLINI P., FACCINI F., PICCAZZO M. (2006). Geomorphological hazard and tourist vulnerability along Portofino Park trails (Italy). Natural Hazards and Earth System Sciences, vol. 6, p. 563-571, ISSN: 1561-8633; BRANDOLINI P., FACCINI F., PICCAZZO M., ROBBIANO A. (2009). Geomorphology, Environmental geology and natural-cultural heritage of Palmaria, Tino and Tinetto islands (Portovenere Park, north western Italy). Memorie Descrittive della Carta Geologica d'Italia (ISSN:0536-0242), 86, 15-28.; BRANDOLINI P., PELFINI M. (2010). Mapping geomorphological hazards in relation to geo¬tourism and hiking trails. In: REGOLINI-BISSIG G.; REYNARD E.. Mapping Geoheritage - Travaux et Recherches. Institut de Géographie, LAUSANNE, 35, 31-46.; 41. CORATZA P., GHINOI A., PIACENTINI D. & VALDATI J. (2008) – Management of geomorphosites in high tourist vocation area: an example of Geo-Hiking maps in the Alpe di Fanes (Natural Park of Fanes-Senes_Braies, Italian Dolomites). GeoJournal of Tourism and Geosites. Year 1, N° 2, Vol 2. 106-117.; MOTTA M., PANIZZA V. & PECCI M. (2009) – Geomorphologic risk assessment on natural rock wall for free climbing practice. Mem. Descr. Carta Geol. d'It., LXXXVII, pp. 109-122; PANIZZA V E MANCA P. (2006) – *Morfologie di erosione fluviale e fruizione turistica. Un esempio nella Sardegna centro-orientale*. Rivista Geografica Italiana, Firenze, 113, pp. 527-547; PANIZZA M., PIACENTE S. (2014) – Geomorfologia Culturale. 2nd ed., Pitagora, Bologna, 360 pp.; PELFINI M., BRANDOLINI P., CARTON A. AND PICCAZZO M. (2009) – Geotourist trails: a geomorphological risk-impact analysis. In: REYNARD E., CORATZA P., REGOLINI-BISSIG G. (Eds), Geomorphosites, pp. 131-144, Pfeil-Verlag, München.