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Workshop

« Mapping Geoheritage»

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Abstracts

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Session 1
Geoheritage mapping

Assessment and mapping of the geomorphologic heritage of the High Chartreuse Plateaux (French Prealps)

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"The High Chartreuse Plateaux are located in the north-western french subalpine massif of the Chartreuse, between the towns of Grenoble and Chambery. Their morphostructure is a long syncline perched above deep valleys, with a frame of urgonian limestones. A desertic karstic landscape is developed in their surface and huge systems of caves have been explored and studied. These plateaux are protected in a nature reserve. According to the management planning of the reserve which foresees the assessment and mapping of all the natural heritage (biotic and abiotic) of the territory, the managers, in collaboration with the University of Savoie, began a conceptual and methodological work on mapping geoheritage in the reserve. In 2007, one of the karstic plateau of the reserve has been used for testing a geomorphologic map including the signalisation of remarkable geotops, and in 2008 will be done a map assessment of the heritage located close the main footpath. These complementary approaches are both founded on G.I.S. using."

Inventaire et cartographie du patrimoine géomorphologique des Hauts de Chartreuse. Rapport de stage M1 EPGM. Juillet-Août 2007.

Mapping hiking trails in relation to geotourism and geomorphological hazard: some examples of coastal and mountain areas (North-Western Italy)

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The activity of geotourism necessarily involves coming into contact 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. We remark that the demarcation of stretches of trails as hazardous or difficult to access should not be understood as a means of causing alarm, but rather as a useful instrument for risk mitigation.

Climate and meteorological variability play an important role in the increase of both the geomorphologic and environmental hazard levels, triggering debris flows and avalanches, for example. These factors also increase the vulnerability of human visitors, due to the presence of slippery paths, wet rocks, and high temperature and humidity in low altitude and coastal environments, or due to loss of orientation or worsened physical condition in the event of bad weather at high altitudes.

The high-altitude mountain environment, for example, appears to be significantly modified in recent decades due to the rapid and intense reduction in glacier masses, the degradation of permafrost, and the ever-increasing frequency of tourism. Today, alpine skiing, alpinism, and other extreme sports practised beyond walking routes or on paths with limited accessibility are of great popularity. In areas recently uncovered by glaciers, numerous upsetting phenomena are occurring: slopes and valley bottoms are covered with abundant unstable debris, glacial deposits only partially consolidated and often with an ice core are easily dislodged by running water, glacier fronts are sometimes suspended over valley bottoms with the possibility of discharging masses of ice or boulders, and glacier lakes are susceptible to rapid emptying. These progressive climatic variations have led to environmental changes that are rendering several alpine trails impossible to pass, several glacier-covered areas used for summer skiing impracticable, and stretches of excursionist trails inaccessible.

Along the coast, the intense expansion of tourism facilities such as residences, ports, bathing and sporting areas, and an increase in the number of visitors over the last few decades, has caused significant changes in original morphological balances and the natural dynamics of the coastline and the coastal slopes. The growing dispersion of coastal trails, mainly steep seaside access routes at the feet of slopes or cliffs, has necessarily led to an increase in the risk of accident, heightened by the fact that persons using these paths are often inadequately equipped.

In the field of geotourism, we should particularly consider the rapid events that may affect a trail network. These rapid altering events necessitate surveys of hazard levels, which may occur both close to a trail and across a much vaster area.

Along trails, it is necessary to pay particular attention to a series of natural aspects, including the morphological elements of the route, which are not hazardous in the strictest sense, but which may impede or render passage difficult (rocky ground sloping downwards, for example). Weather conditions that may promote geomorphological hazards (increased stream flow, debris flow triggering, snow blankets lasting until late season, ice presence, etc.) or that tend to increase the vulnerability of the average visitor (fog, high temperature, low clouds, etc.) should also be indicated.

The physical and morphological characteristics of trails make their use more or less suitable for different users. There are elements that can be unequivocally quantified (length, difference of level, trail bed type, exposure), others that are tied to the degree of maintenance performed by man (presence of protection elements, fixed cords, walkways, ladders, etc.). Additional elements change in function according to the stability of the substrate or due to the dynamic processes in progress (landslides due to melting snow, erosion by concentrated water run off, occlusion from debris accumulation or glacial deposit, etc.) or to the weather conditions (snow, rain, fog, wind). Several of these aspects may increase the difficulty of passage (slimy rock surface together with rain, poor condition of the protections, etc). On most occasions tourist vulnerability varies in relation to knowledge of the territory, physical and psychological preparation, and equipment: important aspects, but ones that cannot be generalised or coded with certainty.

In the framework of a survey protocol of hyking trails in relation to geotourism, including the compilations of sheets (database) to subdivide path into segments with homogenous characteristics (*Piccazzo et al., 2007, Brandolini et al., 2007, Pelfini et al., 2007a)* we present some examples of Liguria coastal zone and of Lombardia Alps.

PELFINI M., BRANDOLINI P, CARTON A. PICCAZZO M. (2007**)** *Rappresentazione in carta delle caratteristiche dei sentieri ai fini della mitigazione del rischio geomorfologico* AIC Bollettino della Associazione Italiana di Cartografia anno XLIIII n. 126-127-128 aprile-settembre-dicembre 2006, 101-123, ISSN 00449733

BRANDOLINI P., FARABOLLINI P., MOTTA M., PAMBIANCHI G., PELFINI M., PICCAZZO M. (2007) – *La valutazione della pericolosità geomorfologica in aree turistiche.* In Piccazzo M., Bandolini P. & Pelfini M. (a cura di). *Clima e rischio geomorfologico in aree turistiche.* Pàtron Editore, Bologna, 11-27 ISBN 978-88-555-2930-3

PICCAZZO M., BANDOLINI P. & PELFINI M. (a cura di). *Clima e rischio geomorfologico in aree turistiche.* Pàtron Editore, Bologna, 11-27 ISBN 978-88-555-2930-3

Cultural sites in assessment and mapping geoheritage

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There are some world famous sites recognized only as cultural sites although many of them contain important, often unique geomorphological features. They represent various examples of buildings, human settlements, land- and sea-uses, cultural traditions etc. For certain sites the natural conditions, particularly geological and geomorphological landforms and processes, provided an ideal setting in which human works were created. The best examples are famous archeological sites: the Nabataean caravan city of Petra (Jordan) with its red sandstone rock formations, an ancient palace complex of Sigiriya (Sri Lanka) with the granite Lion's Rock and the monolithic cave churches of Lalibela (Ethiopia) with one of the best examples of weathering processes. Unfortunately, these values which could be easily recognized and promoted as significant geosites or geoarcheosites, are not emphasized enough.
Most of the cultural sites are recognized as cultural landscapes, connecting human activity with natural landscape, e.g. the Lavaux Vineyard Terraces (Switzerland), the Curonian Spit (Lithuania/Russian Federation), the Vinales Valley (Cuba), the Rice Terraces of the Cordilleras (Philippines), the Vega Archipelago (Norway) or the Middle Rhine Valley (Germany). However, even in these cases the main attention is focused on the promotion of cultural values rather than geomorphological features.
There are also mountainous areas with spectacular scenery, in which objects of cultural heritage are located, for example Upper Svaneti (Georgia), Thingvellir (Iceland); Mount Lushan National Park (China), Matobo National Park (Zimbabwe) or Mapungubwe (South Africa). Mountainous landscapes influence land-use of an area and settlement patterns.
Meanwhile, the simultaneous occurrence exceptional natural values and rich cultural heritage can contribute to the development of tourism, including geotourism, adding to the attractiveness of an area. Likewise, every protective and promotional activities should not only emphasize the cultural part of a site, but also focus on the unique natural scenery, in which a cultural property has been located. The co-operation between two advisory bodies could permit on fuller valuing of the features of these sites: geology and geomorphology in cultural objects and cultural heritage in geosites.
So during the process of mapping geoheritage it seems to be necessary to look for it also in cultural heritage. The full assessment of geomorphosite should contain not only its geological and geomorphological features but also cultural, ecological (e.g. unique ecosystems or rare species of flora and fauna living there) and tourist potential. Traditional tourist maps with exposed cultural sites can be use and compare with geological maps to create new kind of geomorphosite's map.

Geoheritage in the Sintra Municipality

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Sintra Mountain is the biggest geological accident in the region of Lisbon. It corresponds to a sub-volcanic massif with the maximum altitude of 530m in Cruz Alta that contrast with the plane that surround's it. The North and South surfaces correspond to marine abrasion platforms, the first with altitudes comprehended between 100-180m and southern with lower altitudes (30-50m).

Sintra Mountain has a lithology predominantly granitic, where we can find a set of granitic forms and landscapes. In the presentation we will try to do a first classification of these granite geomorphosites.

Some examples of this geomorphosites can be seen at different scales: megaforms (inselberg of Sintra Mountain); mesoscale forms (block chaos, thors); microforms (anthropomorphic forms).

Besides magmatic there are also metamorphic and sedimentary rocks. The last ones are formed mainly by limestones producing karstic landforms. We can observe superficial and underground forms well developed specially the megalapias of Pedra Furada (already classified as protected area). In the southern coast line one con observe a set of beautiful littoral karst forms developed in pure limestones (the tourist area of Hells Mouth).

The geodiversity represented in the Sintra Municipality and the particular microclimate give birth to a luxuriant biodiversity, where Mediterranean and Atlantic flora cohabite in a small area.

One part of the municipality (the mountain area) is classified as World Heritage, in the component Cultural Landscape, by UNESCO, and almost all the Municipality is included in the Sintra-Cascais Natural Park (PNSC).

Bringing geoheritage conservation underwater: mapping methods and geographical information systems

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A complete and accurate mapping of a coastal area necessarily includes both the description of the shore and the description of the underwater side of the coastline. However, while information on mapping of the "on land" coastal features are largely available, methods for the underwater geoheritage mapping and assessment is seldom reported (Orrù et al., 2005), especially if not focusing on benthic communities (Bianchi et al., 2003). The importance of considering, in association with coastal landscapes, submerged ones has been largely reported, according to the fact that it seems reasonable to consider as a *unicuum* two environments that show common processes and landforms, both inherited by past sea levels and present-day dynamics. Nevertheless, studies on the conservation of submerged landscapes achieved consideration only in the last years, registering a substantial delay in comparison with the terrestrial geoconservation concepts (Panizza and Piacente, 1993; Firpo and Carobene, 2005; Reynard, 2007). This occurred because of the physical and social division between the two realms, the different consideration of a marine or terrestrial territory and in their management and touristic exploitation.
The different methodologies in geomorphological sampling in the two realms has not favoured the development of parallel studies. Limits in underwater mapping studies are related to diving time, to the logistic of diving itself (e.g. air in the bottles or safety diving rules) and to the difficult environmental conditions that can be found underwater (e.g. scarce visibility due to sediment suspension). Moreover, diving is an expensive activity (equipment and training) and the sampling effort to map a given surface in the underwater realm are usually greater than in the terrestrial one.
The traditional home of geographical information systems (GIS) in terms of managing, mapping, modelling and making decisions based on spatial data has been in the land-based sciences and professions (Wright and Goodchild, 1997). Therefore, the application of GIS to underwater environments is lacking and is required to fill the gap between marine and terrestrial geoheritage conservation.
In this study we present an overview of the most common mapping techniques and GIS approaches in underwater environment, together with a comparison of the sampling efforts (Marine *vs* Terrestrial environment) in two case studies in the Ligurian coastlines (NW Mediterranean Sea). The results suggest that the landscape is perceived in terrestrial and underwater environment at different spatial scales, despite the continuity between the two realms. This fact should be taken into account both mapping geoheritage underwater and in the related GIS applications.

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Session 2
Geotourism mapping

Mapping geomorphosites for interpretative purpose: Experiences from environmental and heritage interpretation

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In a context of leisure and recreation activities an important production of so-called interpretative or geotourist maps - directed to non-specialists - can be found. An analysis of these maps has shown that they occur in a great variety of styles and that they fulfil different functions: from orientation devices to communication of scientific content (Bissig 2008).
In spite of the abundance of maps, the problem of how geomorphosites can be represented in an immediate and easily understandable form has not seriously been faced. Therefore, a rigorous methodological approach is missing and interpretative maps remain poorly developed.

In order to establish elements for guidelines and principles we looked at parallel research fields. There is a vast corpus of unexploited literature about spatial cognition that can help to understand how spatial knowledge is acquired and that can help to produce better maps (Bailey et al. 2007). Environmental and heritage interpretation researches offer another rich source of principles relevant for geointerpretation. We highlight theoretical and practical aspects from various studies concerning map design and map effectiveness (Kealy 1998, Schoesberger 2007, Patterson n.d.) that should be integrated in geomorphosite mapping for non-specialists.

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Designing a geotourist map : a difficult balance between visual and scientific needs. An example in Tsanfleuron-Sanetsch region (Valais, Switzerland)

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Local public authorities have mandated the Institute of Geography of Lausanne for the realization of a geotourist map in Tsanfleuron-Sanetsch region (Valais, Switzerland). The ski resort *Glacier 3000* finances the project as an environmental compensation for artificial snow coverage.

The glacier of Tsanfleuron flows over a limestone plateau at high altitude (2200-3000 m). This region has been widely studied because of its relative accessibility and its geomorphologic specificities : rheology of a temperate plateau glacier and relationship between the glacier and its limestone bedrock (carbonate crusts). Further downstream, the glacial retreat left limestone uncovered and subjected to active karstic erosion. It forms a marvelous, mostly mineral, landscape.

One of the geotourist map's aims is to show off the gemorphological treasures of this region and explain morphology and dynamics. The main thematic units shown on the map are the karstic area, the pro-glacial area and the glacial retrait stages. Most of scientific information is set overleaf.

The other main goal is to direct and inform tourists : landscape, restaurants, bus stops… The map should be a tool to plan a trip on foot in the whole region of Tsanfleuron, using either public or private transport.

To avoid that complexity makes such a map ineffective, design is indispensable. Starting from this observation, the presentation shows the reflections that lead to the final map : what to keep, what to reject ? Which information or design is the most relevant for each kind of use ? The geotouristic map of Tsanfleuron-Sanetsch is used to experiment diverse methods and principles of map design.

The geotourist map as a tool for promotion of rural areas - the Polish study

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During last fifteen (15) years new geological and geomorphological domain – geotourism has been created and developed in Europe. Its focus is to promote geoheritage and objects of inanimate nature (geological sites, areas) as well as to interest tourists the unusual geological world. In accordance with definitions of geotourism (Słomka, Kicińska 2004) and geomorphosite (Panizza 2001, Panizza & Piacente 2003) this new geological field contains geological and tourist aspects and its main goal is to promote, preserve, protect and to teach people about geoheritage.
To be more useful for tourists geotourism needs scientific materials prepared for people not familiarized with geology. One type of these materials are geotourist maps.
During last few years there have been published a few maps so-called “geologic-landscape”, “geologic-tourist” maps or “geological map for tourists” which tried to complete all information important for geotourism. Polish Geological Institute together with university scientists have published a few maps of this type during last 12 years. In the same time other governmental or local administration institutions have tried to find out the best way to present their interests, aspirations in case to promote and develop local rural areas. They usually used very simple topographic maps as an underlay for tourist infrastructure and objects, sites attractions they wanted to promote. However the ill-considered mixing of data had different results.
Up till now there is no one, defined and recommended by scientists graphical presentation of geoheritage, but it is clear that this kind of maps cannot describe only geological and geomorphological value. It should not only present these types of data but also help in regional or local development by promotion of ethnic culture, rural works of art, usually based on local geographical and geological conditions, important local sites of preservation (nature reserves, national and landscape parks, etc.) tourist infrastructure (car parks, hotels, restaurants, etc.) and other sites of interest.

This paper, showing a few polish examples of geotourist maps, is aimed at discussing their contents and preparation. Maps prepared by local administration can be a good example of local needs and aspirations. The best way to promote geotourism and geoheritage among tourists seems to be the cooperation during process of map preparation between local administration, scientists and other local organizations. It will enable to print a geotourist map with diverse data (geology, nature, tourist infrastructure, cultural attractions, etc.) which can enrich the map about all information needed to plan and carry out the geotourist tour.

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Mapping geoheritage and geotourism. A contribute based on the Portuguese Limestone Massifs Example.

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When mapping Geoheritage and Geotourism is of uppermost importance to identify, to attribute a spatial location, to evaluate, preserve and promote the geomorphosites, other geosites and geotouristic information. So, the way to show all these items is quite an important issue, because it involves the communication of a message from a scientific source to the public in general who are the potential users of the maps.

As the matter of fact, geomorphic landscapes are a part of the natural scientific resources, and are of great importance either for the reconstitution of the Earth's evolution, or for the history of man's impact in the landscape.

Normally, in the cases wherein the Natural Heritage is something tangible, like fossils or minerals, dinosaurs' footprints or a rare sedimentary or volcanic sequence, it is considered worthy of preservation. Unfortunately, the Geomorphic Heritage values are only taken into account in those cases in which the preserved morphology has exceptional features from the landscape point of view. This idea must be contradict because there are a wide range of geomorphosites and other geosites that need to be classified, preserved and revealed to the interested public.

To do the dissemination of the geoheritage and geoturistic information one must establish a map legend to express ideas, forms of relief or landscapes. This information can be translate by point, line or area symbols. The symbols have to be simple to understand by persons with small or none particular knowledge.

In this presentation we will discuss different symbols and legends to translate geoheritage and geotouristic information of the Portuguese limestone massifs. As there is a great diversity of geomorphic frameworks, evolution and characteristics, the example of the Portuguese limestone massifs are a good one to practice and evaluate different symbols to represent geoheritage and geotourism.

The Portuguese Limestone Massifs are good examples of the geomorphic heritage contribute for the values to preserve definition:

1) Arrábida Massif; 30km South of Lisbon and in the littoral area; higher reliefs in anticline structures, such as Formosinho (501m) and monocline structures (cuestas); constitutes the Arrábida Natural Park (PNA).

2) Montejunto Massif; 50km North of Lisbon; highest point in the anticline of Montejunto top (666m); located within the Protected Landscape of Montejunto Massif (PPSM).

3) Estremadura Limestone Massif (MCE) in Central Portugal; 20km far from the Atlantic Ocean and 100km North of Lisbon; moderate altitudes (680m) in reliefs developed in anticline structures and in plateaux tectonically uplifted; major part constitutes the Natural Park of Aire and Candeeiros Mountains (PNSAC).

4) Sicó Massif; the northern one; highest elevations in Sicó Mountain (553m) and Alvaiázere Mountain (618m); extension of 430km^2.

Geotouristic Map of the Montejunto Protected Landscape. An example of a Limestone Massif – Portugal.

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The present work arises within the framework of the recently founded Portuguese Association of Geotourism (APGeotur), and reflects an attempt to develop the uprising theme of Geoheritage in the context of the Natural Parks and Reserves in Portugal.
One can realize that depending on the geomorphologic context of the area, different proposals of Geoturistic maps can be found. This poster reflects the methodology that is being applied in the context of the Protected Landscape of Montejunto Massif (PPSM).
Located at approximately 50 km North of Lisbon, this limestone massif reaches an altitude of 666m above sea level. It clearly outcrops from the surrounding landscape: to the East lies the Tagus subsiding Quaternary basin and to the North and South are located the Bombarral and Arruda sub-basins respectively.
Since the Montejunto Massif is integrated into a protected area, numerous trails have been signed, allowing the visitor to travel throughout the park, establishing different routes, covering the park within its limits. However, there is scarce information regarding the geomorphologic aspects of the limestone massif, such as the tectonic genesis of the spectacular limestone scarps (used, for instance, for climbing sports), the karstic processes involved in the formation of rock depressions (dolines), caves or speleothems within some caves, etc. Unfortunately there is no information combining these two perspectives: tourist information with geoheritage and geomorphosites information. That should be written down in the geotouristic map.
This map involves several phases of construction: (1)-Collection of the existing information (publications, papers, brochures); (2)-Aerial photointerpretation; (3)-Geomorphologic survey and field mapping (1:10 000 or larger, depending on the size of the area, to 1:25 000); (4)-Simplification of the geomorphologic information, correct identification of the geomorphosites, addition of other geosites and other geotouristic information (network of trails and roads and possible proposal of new trails, etc.); (5)-Creation of a short glossary and sketches to illustrate the main geomorphologic features existing in the area and allowing a better understanding of the local landforms; (6)-Geotouristic (or Geoheritage) Map (the final print scale should always be smaller than the field mapping).
The last phase is the one to witch we should pay more attention, as it is related to the core subject of mapping geoheritage and geotouristic information. In the poster presentation we will discuss a specific proposal of legend adapted to the Montejunto Massif geomorphic characteristics.

Poster Session 1
Geoheritage mapping

Bringing geoheritage conservation underwater: mapping methods, GIS and perspectives from the "Isola di Bergeggi" marine protected area (Ligurian Sea, NW Mediterranean)

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The valorisation and conservation of the geological heritage assumed in the last years a growing importance, leading to place side by side biodiversity and geodiversity concepts (Brilha, 2002). In Italy, studies on the valorisation of the geological heritage are relatively young (Panizza and Piacente, 1993; Firpo and Carobene, 2005), and are mainly focused on the terrestrial environment. In the marine realm things are quite different: the difficulties in mapping data underwater and, for authorities and users, in conceiving the marine environment as a territory (Bianchi et al., 2003), represent two major limits for the valorisation and the subsequent touristic exploitation of submerged bio- and abiotic resources. The Italian law 394/91 (general policy on marine protected areas) provides for the valorisation and protection of the ecological, biological and geological heritage in marine protected areas. This perspective is suitable for effective nature conservation because there is no real separation between geological and biological processes (Rovere et al., 2006; Rovere et al., In Press). Nevertheless, while the valorisation and cartography of ecological resources has strong roots in Mediterranean marine science and is frequently reported in literature (Bianchi et al., 2003 and reference therein), the valorisation of the abiotic features is seldom reported (Orrù et al., 2005).

Direct and indirect samplings were carried out in the marine protected area "Isola di Bergeggi" (Italy, NW Mediterranean Sea) in order to map the morfobathymetric, sedimentological and geomorphological features. The position of each dive was established using GPS and results were included in a geographical information system using Esri ArcGis 9 software. The value of abiotic resources in the study area was codified using GIS-based techniques and dividing the study area into 100 × 100 m squares, and a map of the geomorphological emergences of the study area was created. To the abiotic features of each square was assigned a score calculated from the scientific values and one from the touristic value. Using linear regression scientific and touristic values were correlated. Moreover, a scheme for evaluating accessibility of submerged sites was proposed.

The results allowed to recognize zones of high scientific and touristic value in the study area, and showed that the correlation between these two aspect is often high. The use of GIS-based techniques to map abiotic values in the study area, coupled with the accessibility scheme and with the comparison between scientific and touristic values is here proposed as a tool for the evaluation and management of marine geomorphological emergencies and submerged geomorphosites.

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Bringing geoheritage conservation underwater: mapping methods in the shallow water; the experience in Sigri bay (Lesvos Island, Greece).

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A complete and accurate mapping of a coastal area necessarily includes both the description of the shore and the description of the underwater side of the coastline. However, while information on mapping of the "on land" coastal features are largely available, methods for the underwater geoheritage mapping and assessment is seldom reported (Orru et al., 2005), especially if not focusing on benthic communities (Bianchi et al., 2003). A limit in underwater mapping approaches is related to the diving time and thus, to the logistic of diving itself (air in the bottles, safety diving rules, etc.). The presented experience is based on a simple methodology for mapping the geoheritage in shallow waters (about 5 m depth) through snorkeling surveys. The surveys were carried out in Sigri bay (Lesvos Island, Greece), presently included in the proposed Western Lesvos Marine Geopark (Zouros 2007). Underwater transects, performed by snorkeling, allowed to characterise the submerged beach (sediments sampling and granulometric analyses), to identify geomorphosites (beach rocks, tafoni structures, sea notchs), shallow waters habitats (seagrass meadow), as well as exceptional forms (underwater fossil trunks).

The experience resulted in a relevant amount of data useful to create a map of the area, in a relative simple way. In addition, during the survey, sites of particular interest were identified, that are not only scientifically relevant but that can be target of touristic underwater enjoyment purposes (Orrù et al., 2005), and included in a geoheritage-geotouristic map.

The possibility to transfer the experience in the coastal area of Piani d'Invrea, included in the Beigua Geopark (Liguria Region, Italy) is envisaged. Despite the heavy touristic impact beginning in the '60s, this area still preserves an important natural heritage (geologic, geomorphologic and biologic) that merits to be better known (Carobene & Firpo, 2005). According to the encouraging experience in Sigri bay, the mapping of the shallow water heritage would certainly increase the scientific knowledge of the area, as well as the geotouristic offer of the Geopark.

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Bringing geoheritage conservation underwater: an example of ecotypological approach from the Punta Manara coralligenous seascapes (Ligurian Sea, NW Mediterranean)

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Recent trends in geomorphological research include a greater emphasis on investigations containing some explicit ecological component (Urban, 2006). The link between geomorphology and ecology represent a theme of great interest, especially considering that geomorphic processes shape the distribution of biota, but conversely biota can modify geomorphic processes and landform (Stallins, 2006). Therefore, the interdisciplinary nexus between geomorphology and ecology could find application within the concept of 'geoheritage conservation' (Reynard et al., 2007). Here an ecotypological approach (Bianchi & Zurlini, 1984) to identify submerged geosites is proposed. The approach was applied at Punta Manara (Ligurian Sea, NW Mediterranean) to the coralligenous, a precious Mediterranean seascape characterized by the presence of calcareous algae able to build thick frameworks where strong interactions between geomorphological and ecological processes take place (Ballesteros, 2006). Rocky outcrops characterized by coralligenous assemblages were investigated in the field by SCUBA diving and both abundant benthic species and geomorphological features were recorded underwater. Cluster analyses performed on both biological and geomorphological datasets allowed to identify geomorphic typologies (mesotypoligies) and biotypologies. The comparison of the clusters identified by the two analyses revealed ecotypologies with both biological and geomorphological homogeneous characteristics. Within each homogeneous ecotypology, the quality of both biological assemblages and geomorphological characteristics were then evaluated on the basis of international documents, conventions and previous literature.
Our results provide suggestive evidence that geomorphological and ecological quality could be related. The ecotypological approach used proved efficient in determining homogeneous ecological categories, useful for ecosystem evaluation, environmental thematic mapping and geoheritage valorisation.

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Conserving abiotic natural heritage in Slovenia

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ERHARTIČ, Bojan. Landforms as Geodiversity (Geomorphological Natural Heritage) (in Slovene language). *Dela*. [Tiskana izd.], 2007, 28, str. 59-74, ilustr. http://www.ff.uni-lj.si/oddelki/geo/Publikacije/Dela/files/Dela_28/05_erhatic.pdf.

Summary

It is believed that we should not only tolerate difference but also celebrate it. The trend towards the value of diversity has nowhere been more evident than in the field of biology. In recent decades, the growing concern about species extinction and the loss of habitats has led to some important international environmental agreements. Although geological and geomorphological conservation has been practised for hundreds of years, most nature conservation organizations are still orientated mostly towards wildlife and biodiversity issues.
Geologists and geomorphologists started using the term geodiversity in the 1990s to describe the variety within abiotic nature. Geodiversity is seen as the diverse and complex connection of geological, geomorphological and soil features and processes in a defined area.
Slovenian Nature Conservation Act does not mention geodiversity but it defines some elements of nature that fit the term. According to the act valuable natural features are geological phenomena; minerals and fossils and mineral and fossil sites; surface and subsurface karst features; caves; gorges and other geomorphological phenomena; glaciers and glacial forms; springs; waterfalls; rapids; lakes; bogs; brooks and rivers with banks; sea-shore; ecosystems; landscape; and designed landscape. Slovenian legislation defines 10 different kinds of valuable natural features, at least four of them correspond to the term geodiversity: surface geomorphological, underground geomorphological, geological and hydrological valuable natural features. However, other types of valuable natural features may contain geodiversity as well.
It does not make sense to protect all diversity of abiotic nature, but we have to value and protect the most valuable parts of it. Thus a discussion of the specific types of value is needed.
The article addresses the problem of evaluating geodiversity. Values of (valuable) natural features can be classified into intrinsic, cultural, aesthetic, socio-economic, functional, geosystem, research and educational ones.
Intrinsic values refer to the ethical belief that some things (e.g. the geodiversity of nature) are of value simply for what they are rather than what they can be used for by humans (utilitarian value). This is the most difficult value to describe since it involves ethical and philosophical dimensions of the relationship between society and nature. Geodiversity is an intrinsic value in the same way as biodiversity, but it also has other values.
The examples of cultural values of geodiverstity can be found around the world in forms of mythological explanations of landforms, archaeological sites, historical places and spiritual values. Many societies feel a strong bond with their physical surroundings and value these ties for cultural, as well as economic reasons.
The aesthetic values of geodiversity refer simply to the visual appeal (and that of other senses) provided by the physical environment. This may be through landforms at all scales from mountain ranges to small boulders which all have a certain value because of the

diversity of topography they provide for local people or travellers. Landforms are undoubtedly undervalued as an element of landscape since there is a number of recreational activities (e.g. skiing, climbing etc.) that require specific landscapes.

Economists have attempted to put a financial value on all environmental assets, but many geological materials have more than a theoretical economic value. Economic mineral resources are usually classified into mineral fuels, specific minerals and construction stones, but the economic value of the abiotic environment should also include soil and other values and resources. Valuating natural heritage is problematic because it cannot be treated as market goods. Still it has its own price since it can be valued regarding to the benefits that it provides. We can use a WTP (willingness to pay) approach – how much money an individual is willing to pay for natural heritage.

Functional value has rarely been discussed in nature conservation, but it is clear that soils, landforms and rocks all have a functional role in environmental systems. Geodiversity has a functional value in providing the essential substrates and abiotic processes, which maintain physical and ecological systems at the Earth`s surface and thus underpin biodiversity. The land surface also provides a platform for all human activities. A combination of landforms, bedrock types or soils make some areas best suited for agriculture, others for tourism. Geodiversity therefore results in a diversity of utilitarian functional values of different parts of the landscape.

The physical environment generally plays a huge role in providing diverse environments, habitats and substrates that create biodiversity. Engineers and ecologists are more and more aware of the need to understand the processes and patterns in the physical environment if they are to manage processes and habitats successfully. Among physical (geo)factors that influence biodiversity, altitude and aspects rate as two most important. The physical environment is a laboratory for future research and is often the only field site which can provide a reliable test of many geological and geomorphological theories. We need to conserve some landforms (geomorphosites) for research and education purposes. By studying the dynamics of abiotic natural systems, such as rivers, glaciers, coasts etc., we may be able to predict how land and coastal processes will operate in the future.

The increase of public interest in geodiversity demands the redefinition of some concepts as well as an inventory and reevaluation of existing methodology. Only in this way we will be able to point out the most valuable features of geodiversity, market them in appropriate way and conserve them for the future.

The valorisation of high mountain geomorphosites using dendrogeomorphology: the case of Marlet Glacier (Solda Valley, Central Alps) and Miage Glacier (Aosta valley, north-western Italian Alps)

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During the last decades, the increasing interest in high mountain environment, has conduced to an increment of tourist frequentation also in areas characterized by presence of glaciers. These landforms have been progressively classified as geomorphosites because of their scientific, cultural, historical, aesthetic and economic value. Moreover, they are rapidly evolving and their recent geomorphological history is documented by morphological features, such as moraines. Glacial deposits can be used to reconstruct glacial fluctuations by applying biological dating methods like lichenometry and dendrochronology. In particular, the last one requests the presence of a tree or shrub cover: growing rhythmically plants produce annual rings that can be dated to obtain the minimum ages of recent moraines and recently deglaciated areas.
Studying glacial landforms by dendrochronological methods and reconstructing glacial history using tree rings can increase scientific and didactic value of this class of geomorphosite: it allows to deepen geomorphosite knowledge and so to raise the number of attributes to improve.
Marlet Glacier (Solda Valley, Stelvio National Park, BZ, central Alps) is a debris-covered glacier in rapid retreat characterized by a debris layer totally overgrowing ice beneath. It shows a complex moraine system with two principal ridges deposed during Little Ice Age and an older amphitheatre composed by four moraine ridges and colonized principally by European larch (*Larix decidua* Mill.) and stone pine (*Pinus cembra* L.). Dating the oldest trees growing there, we obtain an age of deposit older than 1300 and we also try to establish the order of moraine deposition to reconstruct past glacier features. The results obtained from these analyses improve scientific value of this geomorphosite and increase interest in it: Marlet Glacier is crossed by an hiking trail that get to refuge high frequented by tourist during summer and where it is possible to observe the entire valley from a spectacular point of view.
The Miage Glacier (Aosta Valley, north-western Italian Alps) is the most important debris-covered glacier in Italian Alps: in the lower part of its tongue is colonized principally by European larch (*Larix decidua* Mill.), shrubs and herbaceous vegetation. It has been proposed as geomorphosite also because of its uniqueness character: it is the only debris-covered glacier in Italy with a tree cover growing on the debris.
Supraglacial trees react to glacial movements (sliding and vertical movements related to freezing and melting processes) assuming characteristic shapes. Moreover, tree rings record debris instability linked to ice sliding down-valley, the transmission of kinematic waves and glacio-karst phenomena. A dendroglaciological analysis carried out on the larches growing on the glacier showed the passage of a kinematic wave that reached first the southern lobe and, a few years later, the northern lobe as demonstrated by the concentration of indicators of growth disturbance (pointer years, abrupt growth changes, reaction wood): in the northern lobe they mainly occurred in the period 1989-1993 (5 years), while in the southern lobe in the period 1984-1990 (7 years). The time lag and the time span between the growth-disturbance signals from the two lobes suggest that the kinematic wave which crossed the glacier tongue in the 1980's seems to have been slower and weaker on the northern lobe. Using tree ages we also determine that larches colonized debris from, at least, 60 years.
In both cases, on Marlet Glacier and Miage Glacier, the use of dendrogeomorphology allowed to increase ecological value of geomorphosites. Tree cover analyses permit to deepen understand past glacial history introducing a paleoclimatic value and the reconstruction of moraine deposition to better explain glacial movements, highlighting the didactic attribute.

Moreover we demonstrated the velocity of glacial geomorphosite changes on yearly scale and on decadal scale, suggesting possible implications in geomorphosite management.

Geomorphological mapping of dynamic processes

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In alpine environments, debris flows are a very dangerous geomorphic process and the main sediment transport agent in mountainous watersheds. In these areas, topographic conditions and land cover often reduce accessibility to conduct complete field surveys as geomorphological mapping. GIS applications using digital elevation models (DEM) in ArcMap software can be used to highlight and map more precisely the main geomorphologic features, to analyse specificities of the hydrographical network and, hence, to evidence the localisation and the potential volumes of sediment supply zones.

This poster presents some applied geomorphological mapping attempts at various scales and with various legends in a torrent located in the right side of the upper Rhone river valley (Switzerland). Example of maps highlight how difficult it is to quantify differences in sediment yields by using a morphogenetic approach, because this kind of mapping allows the distinction of landforms according to the processes, but not to the intensity and frequency of current processes. Moreover, geomorphological mapping based only on field observation is not sufficient for evidencing the importance of sediment storage systems and their potential contribution to debris flow triggering. That is the case of talus slopes and rock glaciers containing permafrost that potentially represent large storage systems of unconsolidated materials, where collapses or debris flows may occur. The ice content and its distribution within the landform, as well as the thermal regime of ice and sediment, are important factors influencing triggering processes, but they cannot be quantified by simple field observation and mapping. Processing within a GIS (e.g. classification of landforms second their dynamics or their position respect to the main channel, but also other spatial analysis) enlarge new opportunities for a more quantitative use of classical geomorphological maps.

Poster Session 2
Geotourism mapping

Geosites in Arrabida Natural Park. A preliminary approach

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The Arrábida Natural Park includes Mesocenozoic terrains, mostly formed by limestone and marls that were surrounded by younger materials of the Tagus basin (from Miocene to present sedimentation). This type of island that belongs to the Occidental Basin is formed by uplifted areas due to late pirenaic orogenic movements, mostly from the upper Miocene, that folded the Jurassic limestone sequences. So, the Arrabida Mountain is a set of low reliefs (maximum altitude is 501m in Formosinho) developed in anticline structures (Formosinho and S. Luís).
The tectonic movements give also place to monocline structures were developed monocline reliefs such as *cuestas*, *crêts* and hogbacks, as well as ortoclinal depressions placed in the soft rocks.
Toward the occidental part of the Natural Park one can observe a very well developed Quaternary marine abrasion platform (Plataforma do Cabo), today placed at altitudes of 150 to 200 meters above the sea level.
All the Natural Park is surrounded by impressive rock cliffs that do the transition with the water, especially in the southern and south-western limits were the dip range from 150 to more than 300 meters. This rocky coast line is interrupted by narrow beaches developed in small bays of outstanding beauty, such as the Portinho of Arrabida beach or the Sesimbra beach and port in a larger bay, both located in the southern border of the Park that faces the river Sado estuarine preserved area.
The preliminary survey of the Arrabida Natural Park geosites shows that there are quite different types of geosites, and that we need to approach them at different scales. The scales range from general overviews (for instance the unique overview of the entire Sado estuary that can be observed from the belvedere of Formosinho, the highest point of Arrabida), with an aesthetic and scientific (geomorphologic) value, to small rounded pebbles (with an almond shape) located in the surface of the Plataforma do Cabo that proves its marine genesis.
Other types of geosites include the Natural Monuments composed by the dinosaur footprints of Lagosteiros, Pedra da Mua and Avelino, the diapiric structure that is responsible by the hill here is place the Sesimbra castle, the hill of the Palmela castle, the *mont anticlinal* of S. Luís, the Alto da Madalena *cuesta*, the different rocky platforms located between the sea level and the Plataforma do Cabo that testify old levels of the sea (some of them with human occupation), as well as an exuberant karstic relief, both on the surface and on the underground.

Creation and test of a mobile geothematic GIS application: a support for reliable geosite data collection, GIS and field mapping activities.

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In the last 10 years, the use of computers for the collection, elaboration and distribution of geological and geomorphological data had a notable development. Many problems, not yet resolved, still concern both the conceptual framework and the practical solutions for field data collection and their transposition into a complete GIS.

Looking for faster and more suitable procedures of field mapping activities, either for research and university teaching purposes, it has been created an application called "SRG^2" (Italian: "*Supporto al Rilevamento Geologico/Geomorfologico*": Support to Geological/Geomorphological Surveys), an extension for ArcPad (GIS-ESRI for palms) developed in Visual Basic. Into ArcPad environment, the SRG^2 application adds a toolbar, vectors and tables made up of several functions for a useful mapping and classification of geological/geomorphological features.
In order to catalogue erosional and depositional landforms and related deposits, the SRG application is structured into 16 layers (shape file format) and associated databases. Beginning from this application, many in-field activities can be developed. Some surveyed features are classified by geometry (punctual, linear, areal) and by related geomorphic process, either endogenic or exogenic (glacial, fluvial, gravity-induced, tectonic, complex, etc.). Further alphanumeric data (morphometrical, chronological, lithological, etc.) are requested to complete description and to support interpretations.

A test for SRG^2 has been performed in the many sites such as Thuras Valley (Upper Susa Valley) with a project devoted to geomorphological analysis in the mountain area of Torino 2006 Winter Olympic Games.
Other project has been conduced on Rivoli-Avigliana Morainic Amphitheatre in order to make a Geosites inventory. The last task has been conduced on the Gran Paradiso National park territory, to survey glacial areas and the whole network paths. Automatic import with legend transposition of field structured geodatabase data allowed immediate creation of publishable maps. This way, the field survey becomes an integral part of a complete and easy-to-update GIS, without other intermediate passages.

GIS and Geomatics applications for evaluation and exploitation of Piemonte Geomorphosites

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Introduction

The present study is carried out within the agreement between Turin's Regional Natural Science Museum and University of Turin, Dep. Earth Science. This is the first of a series of studies concerning geoconservation and geodiversity in Piemonte Region.

In the last few years the use of information technology for collection, processing and representation of data became essential for territorial analysis.
The spread of Internet facilities encouraged the development of very user-friendly applications, allowing anyone to perform interactive operations on geographic data: we have moved around the obstacle of the installation in local of plugins and data-viewer.
The present study shows the steps necessary for evaluation and exploitation of geotouristic sites of the SouthEast part of the Piemonte region., through GIS, Geomatic and Web-based applications,
In the study area, we have selected ten geomorphosites of different interest, but with an overall high didactic value, by which it is possible to understand the geomorphological evolution and the dynamics of some natural process affecting the territory.

Methodology

Collection and organisation of information concerning geomorphosites in prearranged card;
Simplification of cards with the addition of images, pictures and schemes;
Insertion of data in a relational database and georeferencing of data, in order to perform territorial analysis;
Use of aerial orthophotos to make a mosaic to overlay to the digital terrain model;
Recognition of main geomorphological elements;
Production of geotouristic paths;
Export of themes inside a Web-GIS application;
Production of pamphlet in collaboration with local museum.

The study

The present study takes into account a portion of the middle Tanaro Valley, between the towns of Bra and Bene Vagienna , Cuneo province. We have choosed this area because of its geosites of high naturalistic, geological and cultural values, and for the large number of scientific publications produced since 1865 at the hands of notable geologists.
The selected geomorphosites have been evaluated taking into account several parameters: scientific, aestethic and cultural. The economical aspect is not referable as a parameter because the whole area has very high potentiality, due to the proximity of touristic sites such as the Roero and the Langhe hills and the southern Monregalese.
From the inventory cards for each geomorphosite we have worked out simplified interpretative cards with the addition of schemes, pictures and images in order to facilitate comprehension to the general public
To encourage a first approach to the interpretation of landforms we have developed a digital elevation model from aerial orthophotos, with enough details to recognise the main geomorphological elements of the territory. With the orthophotos and the georeferenced geomorphosites we planned to organize a series of geotouristic paths.

All the themes are prone to be inserted into a Web-GIS application based on open-source programs.
The structure is composed in four main components:

- Apache web server (Multiplatform)
- Uminn MapServer (Used to represent in Internet geospatial data. Multiplatform)
- MySQL (Relational Database. Multiplatform)
- PMapper (Web mapping interface developed in PHP. In team with MapServer and a Web Server is used to create digital maps suitable to be consulted through different Web browser).

The exploitation of geomorphosites and the spread of their scientific knowledge is make in harness with territorial facilities such as local natural history museums: their experiences are absolutely necessary to obtain good results in a strategy of Geoconservation. To support scientific communication an interactive animation is under project, showing step by step the geomorphological evolution of the studied area.

The challenge of mapping alpine geosites to small scale

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In the context of a Ph.D. work in progress about the geoheritage of the alpine range, an assessment of all the geosites open to visitors has been done. Mapping these sites for a synthetic representation to small scale for several types of public and media induces different and specific problems and difficulties. The result exposed for the workshop should be discussed and compared with other similar works.