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A GEOMORPHOSITES INVENTORY IN CENTRAL PIEMONTE (NW ITALY): FIRST RESULTS

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ABSTRACT: A. Costamagna, A Geomorphosites inventory in central Piemonte (NW Italy): first results. (IT ISSN 0394-3356, 2005).
The first results of a research project, promoted by the holding company of Parks and Wildlife Reserves of Asti, realized by the Department of Earth Sciences of the University of Torino, are exposed. The aim of the work is to carry out a Geosites inventory in an area made of the hilly reliefs of central Piemonte Region (NW Italy) and of nearby sectors of the Po Plain, in order to seek for natural resources for the promotion, exploitation and management of sensitive environment. The proposed research methods concern geosites of geomorphological nature ("Geomorphosites"), that is: landforms that mark out a physical landscape, reveal its evolution and to which a value can be attributed. In the surveyed area three geomorphological units exist: hilly ranges; Pleistocene plateaus; main surface of the Po Plain and present flood-plains. The inventory was founded on bibliographic research and land survey, that lead to single out and classify the most representative geomorphological objects. In order to select Geomorphosites starting from the surveyed features, an evaluation method based on the assessment of fundamental (Factors) and secondary (Indicators) criteria was applied. Through the former ones a index was calculated that expresses scientific value of the sites. The latter ones were used, in different quantities and with variable values according to each case, in order to assess the weight of the factors. The information obtained was recorded in a "Database of geological heritage", built according to the rules advised by the Italian National Geological Survey (S.G.N.). This database allows to draw descriptive forms referred to each Geomorphosite, and it is the essential digital layer to implement in a Geographic Information System.

RIASSUNTO: A. Costamagna, Censimento di Geomorfositi nel Piemonte centrale (Italia nord-occidentale). *(IT ISSN 0394-3356, 2005).*
Sono esposti i primi risultati di un progetto di ricerca promosso dall'Ente Gestione Parchi e Riserve di Asti e realizzato dal Dipartimento di Scienze della Terra dell'Università di Torino. Scopo del lavoro, che consiste nel censimento di geositi in un'area costituita dalle colline del Piemonte centrale (Italia NW) e da porzioni limitrofe della Pianura Padana, è la ricerca di risorse naturali al fine di promuovere e valorizzare un territorio della Regione Piemonte sensibile dal punto di vista ambientale. I metodi di ricerca esposti riguardano i geositi a carattere geomorfologico ("geomorfositi"): forme che caratterizzano un paesaggio fisico, ne interpretano l'evoluzione e a cui sia possibile attribuire una valenza. Nell'area in esame, contraddistinta dall'elevata geodiversità, sono presenti tre unità geomorfologiche: rilievi collinari; altopiani pleistocenici; superficie fondamentale della Pianura Padana e alvei attuali. L'inventario si basa sulla ricerca bibliografica e su rilevamenti di terreno, in seguito ai quali sono stati individuati e classificati i siti più rappresentativi dei diversi sistemi geomorfologici agenti. Per selezionare i geomorfositi a partire dagli elementi rilevati si è applicato un metodo di valutazione basato sulla ponderazione di criteri fondamentali (Fattori) e secondari (Indicatori). Per mezzo dei primi è stato calcolato un indice che esprime la valenza scientifica relativa dei siti. I secondi sono stati usati, in numero e con valore diversi a seconda dei casi, per stimare il "peso" dei fattori. Le informazioni ottenute sono state archiviate in una "Banca dati delle singolarità geologiche", costruita in base al modello proposto dal Servizio Geologico Nazionale italiano (S.G.N.). L'archivio digitale consente di redigere per ogni geomorfosito schede descrittive sintetiche ed è una base di dati essenziale per implementare un Sistema Informativo Geografico.

Keywords: Geomorphosite, Inventory, Geomorphology, River erosion, Geodynamics.

Parole chiave: Geomorfosito, Inventario, Geomorfologia, Erosione fluviale, Geodinamica.

1. INTRODUCTION

W. A. P. Wimbledon, a well-known British geoscientist, wrote in 1999 that geoconservation was like Cinderella among the branches of environment protection.

The basis of such an outspoken statement is the bitter reflection that, although for at least two decades – in Europe as in other parts of the world – many projects were developed to protect and to promote "Geological Heritage", the reasons of scholars were still marginal in public feelings and in the framework of land-use planning and management, with very few examples of actual applications.

Within the field of Nature conservation and in comparison with other disciplines (Botany, Zoology, Archaeology, ...), the delay of Earth Sciences stems from deep-seated social and cultural reasons, basically linked to lacks in information and popularization of scientific subjects that are both very fascinating and quite complicated.

This dearth of knowledge leads to believe that the Geology's not a dynamic and essential feature of the landscape, but a factor indolent to changes, perceived and appreciated whenever it represents a natural monument, an oddness in physical landscape or, in short, an element of the scenery, static and separated from the land.

It is therefore a widespread opinion that only those places regarded as "beauties of nature" can be seen as "Geological Heritage" and need to be protected (Biancotti, 2002): the Capri Island, the White Cliffs of Dover, the Grand Canyon of Colorado River are all well-known examples that attract scores of tourists.

To this vision, according to which an aesthetic standard is the only criterion useful for the evaluation of physical landscape, can be opposed the idea that every evidence of the Earth's history, being an element of "Geodiversity" (that is the natural variety of geological, geomorphological and soil features and processes; Sharples, 2002), could be considered as an environmental asset. In modern scientific language, these limited parts of a physical landscape, that have a peculiar geological, geomorphological or geoecological significance are called "Geosites" or "Geotopes" (Strasser *et al*., 1995). Geosites (synonymous: Earth science site, geoscience sites) are portions of the geosphere that present a particular importance for the comprehension of Earth history (Reynard, 2003). They are geologically and geomorphologically valuable and sensitive parts of a countryside ("Geotopes"; Stürm, 1994), for which it is reasonable to define an interest for conservation ("Geosites"; Wimbledon, 1995).

The study of geosites is part of a general strategy for geoconservation that is promoted on a national and international level by public institutions, nature conservation organizations and the Earth Science community. The projects and activities promoted in order to achieve these aims are based on the assumptions that any geological heritage, being a trace of the Earth's past, could never be replaced once it is destroyed, and that every variation in the geological balance of a territory, be it natural or accelerated by man, carries along direct consequences on the ecosystems it contains.

Moreover, if geosites, once selected, are exploited and made usable, they can turn into important natural resources (Panizza & Piacente, 1999), achieving the twin goals of conserving a healthy environment and enhancing sustainable economic development by the promotion of "Geotourism".

Within the planning process the term "geotope" (*s. str.*), meaning "a distinct part of the geosphere which document the earth's history" (Stürm, 1996) or "the smallest geographically homogeneous spatial unit" (Poli, 1999), could play the same role as the term "biotope" ("a physical environment unit where a vegetable or animal population, or a biocenosis dwell"): this word could be rightfully included into environmental laws.

Whereas for Earth Sciences every meaningful geological object is unique, and could therefore be considered a geotope, it seems unavoidable to consider the problem of selection and evaluation of geosites, which is basically "a way to objectifying the subjectivity" (Gonggrijp, 1997) and requires to develop methods fitting to the different environmental contexts.

According to the disciplines of Earth Sciences, geosites can be classified as follows: geomorphological, structural, sedimentological, stratigraphical, mineralogical and petrographical, paleonthological, hydrogeological.

A geosite of geomorphological nature ("Geomorphosite") is a landform to which a value can be attributed; a geomorphological resource is a geomorphosite that can be used by society (Panizza, 2001). The attributes that may confer value to a geomorphosite are: scenic; socio-economic; cultural; scientific. The scientific value may be derived from the assessment of different features, for instance: rarity; integrity; exemplarity; working scale. The very aims of the studies can be manifold: creation of catalogues; environmental impact assessment; exploitation (*lato sensu*).

The following focus on the presentation of a study case that is one of the possible solutions to these methodological problems (highlighted according to Grandgirard, 1999).

This paper sums up the first results of a research project promoted by the holding company of Parks and Natural Reserves of Asti, and carried out by the Department of Earth Sciences of the University of Torino (Italy). The aim of the work is to carry out a Geosites inventory in an area made of the hills of central Piemonte Region and of nearby regions of the Po Plain (NW Italy), in order to seek for environmental resources and possible means of eco-sustainable management.

This study is being developed by four research teams that work together scanning the landscape to find out geomorphological, hydrogeological, stratigraphical and paleonthological features, and sharing the same system to register and synthetize data. This is the "Experimental form for the inventory of Italian Geosites" (Brancucci *et al*., 1999), a method proposed in 2000 by the Italian National Geological Service Survey (S.G.N.) in order to receive reports concerning geological heritage and to create a benchmark database useful in town and country planning and in scientific research (Centro Documentazione Geositi, 2000).

Methods and examples provided concern geosites that can be classified as Geomorphosites, that is: landforms that mark out a physical landscape and reveal its evolution (Costamagna, 2003).

2. THE LANDSCAPE OF CENTRAL PIEMONTE

The geosite inventory is carried out in an area of central Piemonte Region whose hub is the city of Asti and whose limits are (refer to Fig. 1):
- to the north: the Po River, between Moncalieri (Torino) and the mouth of the Tanaro River;
- to the east: the distal sectors of the Tanaro, Bormida and Orba rivers;
- to the south: the Rea valley, the middle Belbo valley and the outcrop bottom limit of the "Formazione gessoso-solfifera" (i.e. Messinian "gypsiferous-sulphurous" Formation), between Bene Vagienna (Cuneo) and Rocca Grimalda (Alessandria);
- to the west: the route of the Torino-Savona Highway, between Moncalieri and Bene Vagienna.

The physical landscape of central Piemonte is characterized by hilly ranges connected with gently undulating table-lands and plains: this territory can be divided into peculiar areas, which come from a complicated evolution that the following paragraph summarizes.

2.1 Geological framework

Geodiversity is the main feature that marks out the surveyed area, owing to a heterogeneous substratum, both from lithological and structural points of view, to recent tectonics movements and to climatic changes that took place between upper Pliocene and Olocene.

The lithological complexes outcropping have

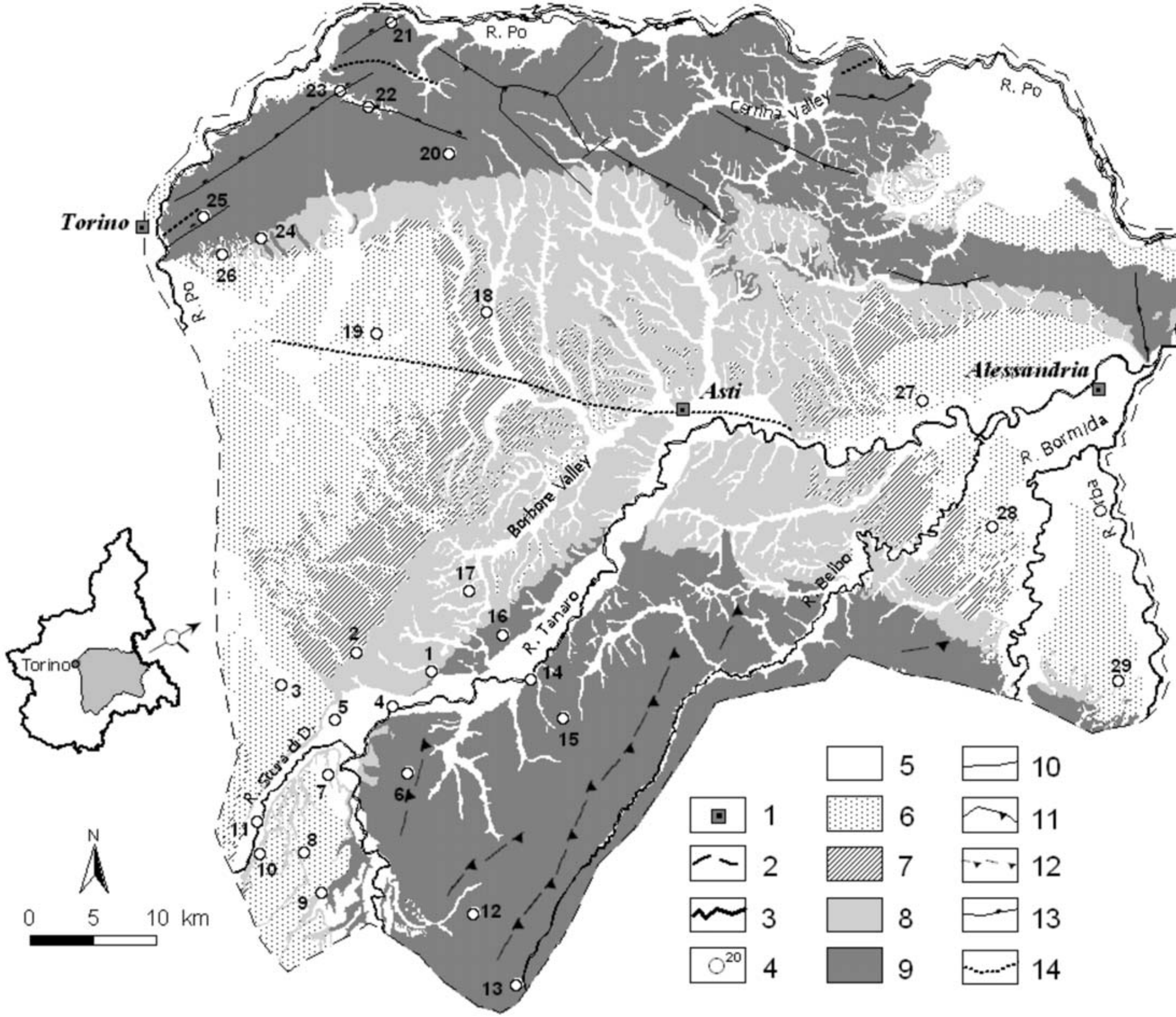

Fig. 1 - Location and geological outline of the surveyed area. Conventional symbols: 1) chief town of Province; 2) boundaries of the area; 3) main riverbeds; 4) selected geomorphosites (see Table 4) up to June 2003. This inventory will be completed by January 2004. Lithology: 5) recent fluvial sediments and high river beds (Olocene); 6) pediments, loëss deposits, fluvial and glaciofluvial deposits (Pleistocene - lower Olocene); 7) tide-deltaic to continental deposits of the "*Villafranchiano* auct." succession (lower Pliocene - lower Pleistocene); 8) "*Argille Azzurre*" (clays and marls) and "*Sabbie di Asti*" (sandstones) Pliocene Formations; 9) pre-Pliocene sedimentary rocks of the Tertiary Piemonte Basin. Main structural features: 10) normal and strike-slip faults; 11) thrust faults; 12) cuesta fronts; 13) anticline axes; 14) syncline axes.

Ubicazione e schema geologico dell'area di studio. Simboli convenzionali: 1) città capoluogo di Provincia; 2) limite dell'area; 3) corsi d'acqua principali; 4) geomorfositi selezionati (vedi Tabella 4) a giugno 2003. L'inventario sarà completato entro gennaio 2004. Litologia: 5) depositi fluviali e alvei maggiori olocenici; 6) lembi di glacis d'accumulo, depositi di loëss e sedimenti fluviali e fluvioglaciali (Pleistocene - Olocene inferiore); 7) depositi di ambiente continentale-deltaico del complesso Villafranchiano *(Pliocene inferiore - Pleistocene inferiore); 8) Formazioni delle* Argille di Lugagnano *e delle* Sabbie di Asti *(Pliocene); 9) rocce sedimentarie pre-plioceniche del Bacino Terziario Piemontese. Principali elementi strutturali: 10) faglie dirette e trascorrenti; 11) sovrascorrimenti; 12) fronti di cuesta; 13) assi di anticlinali; 14) assi di sinclinali.*

been classified into five groups (refer to Fig. 1).

Under a structural point of view, the area is as complex as it's interesting, because it lies in the junction zone, either outcropping or buried, between the Alpine and Apennine domains, which converged in the Tertiary (Piana & Polino, 1994).

In short, there are subsident areas alternating with uplifting sectors, and it is possible to distinguish (refer to Fig. 1 and 2) between four main structural units (Carraro, 1996):

- the "Monferrato arc", a complex made up of the "Collina di Torino" (Torino Hill) and the Monferrato hills, that forms a very large area of recent uplift where a North-verging thrust system is overlapped with asymmetric positive antiform structures;
- the "Asti syncline", an E-W structure;
- the Langhe monoclinal structure, made up of sedimentary rocks of the Tertiary Piemonte Basin;

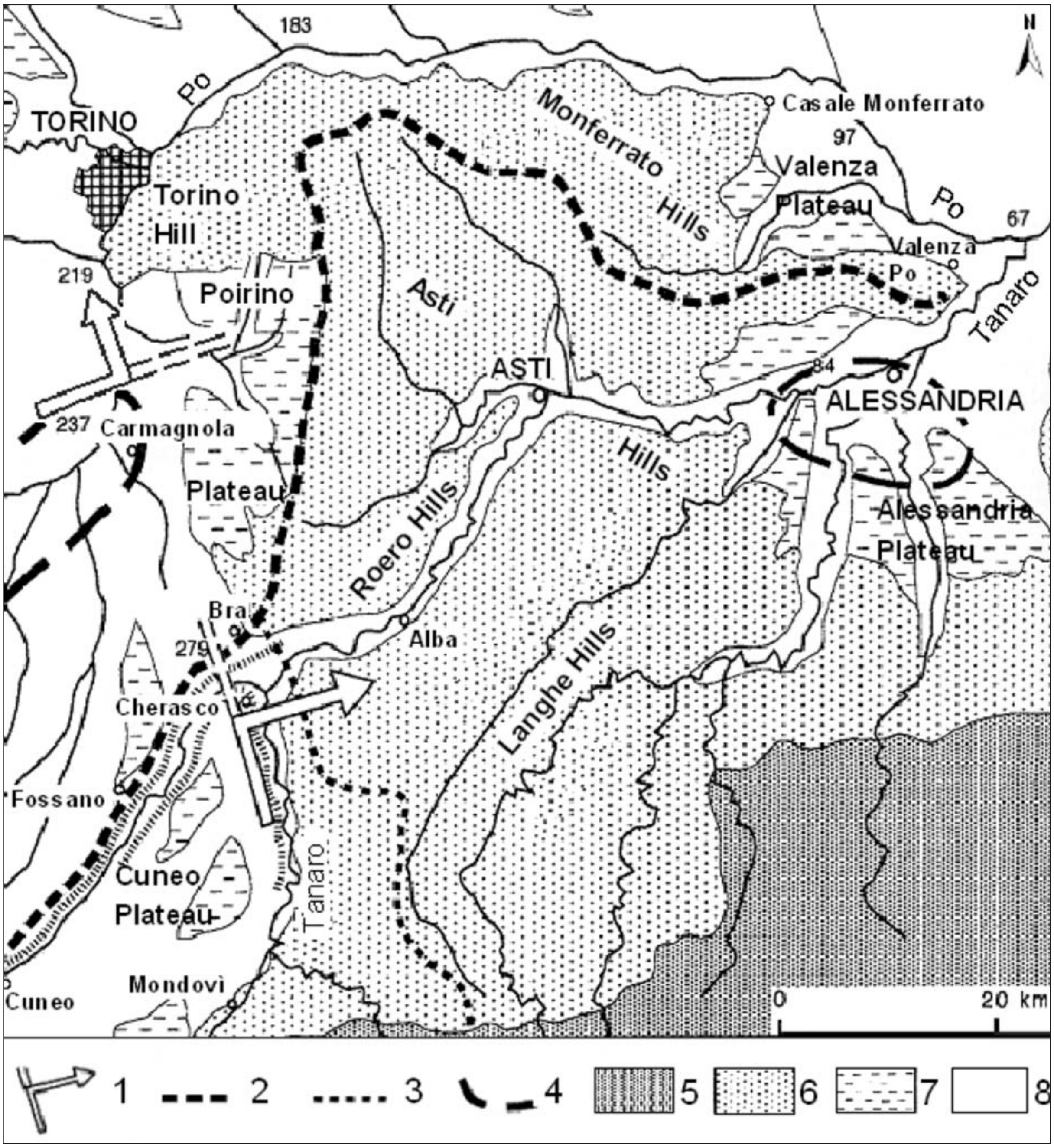

Fig. 2 - Geomorphological outline of central Piemonte. Key: 1) sites of diversion of Tanaro and Po rivers; 2) present-day watershed between Po and Tanaro; 3) watershed between high Tanaro and rivers flowing towards Alessandria, before diversion; 4) approximate boundary of areas in subsidence during Pliocene and Quaternary; 5) Alpine and Apennine mountains; 6) hills; 7) Lower and Middle Pleistocene terraces; 8) main surface of the Po Plain and current high river beds (from Castiglioni, 2001, modified).

Schema geomorfologico del Piemonte centrale. Legenda: 1) aree di deviazione dei fiumi Tanaro e Po; 2) spartiacque attuale fra il Po e il Tanaro; 3) spartiacque fra l'alto Tanaro e i fiumi confluenti nel bacino di Alessandria prima della cattura del Tanaro; 4) aree in subsidenza durante il Pliocene ed il Quaternario (limite approssimativo); 5) rilievi alpino e appenninico; 6) colline; 7) ripiani e terrazzi del Pleistocene inferiore e medio); 8) superficie fondamentale della Pianura Padana ed alvei maggiori attuali (da Castiglioni, 2001, modif.).

- the subsident basins around Alessandria, Cuneo and Carmagnola (south of Torino).

2.2 Morphological framework

The geological diversity of the surveyed area matches an equally composite geomorphology. It is possible to divide the landscape in three main geomorphological units (refer to Fig. 2):

- Ranges of hills mostly shaped into Cenozoic sedimentary rocks;
- Pleistocene plateaus;
- Main surface of the Po Plain and present high water beds.

During the Quaternary the southern Piemonte exhibited important variations in the hydrographic pattern, due to significant geodynamic evolution and to climatic changes, that also resulted in deep variations of the landscape (Biancotti, 1979; Biancotti & Cortemiglia, 1982; Biancotti *et al*., 1999; Carraro *et al*., 1995; 1996; Castiglioni, 2001; Gabert, 1962; 1965; Piana & Polino, 1994). Main effects of interaction between tectonics, structure and the weathering were:

- the diversion northward of the Po River, that took place south of Torino and drastically changed the drainage system of central Piemonte;
- the "piracy" and NNE deviation of the Tanaro River, that occurred south of Bra and that – due to a peculiar morpho-tectonic situation – triggered an intense river erosion which also resulted in modelling of new valley bottoms, both in stretch between hills and in plain upstream from the "piracy point".

Above-said events have resulted in a geomorphological rejuvenation that involved the whole of the surveyed territory: the wealth of processes and landforms, both active and residual, is an evidence of the complex evolution of this territory.

The main morphogenetic process is river dynamics: structural, erosion and depositional relict surfaces, incised by present valleys, can be found both in the hills and in the plains (Fig. 3).

High relief energy and strength in river erosion processes are factors that pave the way for mass movements, as is manifest along erosion scarps of terraces and canyons and in the whole of the hilly areas: especially in the Langhe Hills (see below), for structural reasons, endemic rock-falls and rock-slides happen (Fig. 4) as a consequence of continuous and dense downpours. Among the resulting geomorphological units distinct landscapes can be spotted.

Fig. 3 - Treiso "calanchi" (badlands), dug into "Sant'Agata Fossili" Marls by the Seno d'Elvio stream, that flows into the Tanaro River SE of Alba and that cut down an ancient structural surface, visible near the top of this image. These gullies, known as "The Seven Brothers' Rock", are one of the selected geomorphosites. (see Fig. 1, dot No 15).

I calanchi di Treiso, scavati nelle Marne di S. Agata Fossili dal Torrente Seno d'Elvio, che sfocia nel Tanaro ad Alba e ha inciso un'antica superficie strutturale (nella foto in alto). La località, nota come "Bric dei Sette Fratelli" è stata selezionata come geomorfosito (Fig. 1, punto 15).

Fig. 4 - Starting scar and slide plane of the landslide that took place in Somano (Valle Rea) during a continuous and dense downpour that occurred in autumn 1972 (Govi, 1974). This geosite is one of the elements of Geomorphological System No III (see: chap. 4; Fig. 1, dot No 12).

Nicchia di distacco e piano di scivolamento della frana verificatasi a Somano (Valle Rea) durante un alluvione nell'autunno del 1972 (Govi, 1974). Il geosito è uno degli elementi del Sistema geomorfologico III (cfr.: cap. 4; Fig. 1, punto 12).

2.2.1 Hills

The present morphology of hills is conditioned mainly by structural features in the northern sector and by river erosion in the middle-southern one. Three groups of relief are recognizable:

- Torino Hill and Monferrato hills, that lie along northern and north-eastern margins of the area;
- Asti "negative hills" ("*Colline negative*"; Zuffardi, 1915), thus named because they're embedded in the plateau bordering them to the NW; they occupy the central sector of the area and spread along a NE-SW line running between the cities of Asti and Bra;
- Langhe Hills, that are situated SE of Asti Hills, from which they're separated by the wide Tanaro Valley; only the NW sector of the Langhe is included in the surveyed area.

Torino Hill and Monferrato hills

This hilly range is an overthrusting and folded asymmetric relief, whose northern side is steeper due to the vergence of the main tectonic structures. The hills are intensively eroded by an inner stream network often adapted to the structure and are undermined at the base by the Po River, that runs in a periclinal direction touching the hills between Torino and Casale Monferrato. The two reliefs are separated by the Leona stream, that feeds the Po east of Chivasso, and the Traversola stream, left tributary of the Borbore River, that flows into the Tanaro River nearby Asti. This morphological difference is the surface expression of the *Riofreddo* Shear Zone (Piana & Polino, 1994), a paleogeographic and structural distinction between two sectors of a pre-messinian substratum: the western one, that has Alpine pertinence (Torino Hill), the eastern one, that has Appenine pertinence (Monferrato hills).

Asti Hills

The Asti Hills are mostly shaped in the form of hog's back ridges, separated by valleys deepened into sandy and pelitic rocks, whose heads are usually modelled in steep slopes, ravines, "hoodoos" and other erosion landforms. The stream network that drains these hills is superposed to a paleosurface that can be recognized at the top of the main divides. The relief was modelled as a result of upstream incision of the rivers flowing into the Po around the subsident Alessandria plain and of accelerated erosion following the capture of Tanaro River, whose effects are clear in the area closest to the piracy point.

According to the structure and the lithology of the bedrock, two hilly sectors can be distinguished:

- Astian reliefs, shaped in the fold limbs of Asti syncline, whose axial zone, buried by river deposits, is encircled by the ridges;
- Roero hills, set in the NW branch of Langhe monoclinal structure (see below), whose they represent an ideal continuation.

Langhe Hills

The Langhe Hills are shaped in the sedimentary rocks of Tertiary Piemonte Basin, that have, on a large scale, a monoclinal structure plunging to the NW. Apart from the southern Langhe, where the almost total erosion of Oligocene marine deposits resulted in partial exhumation of the Middle Paleogene morphology, the present Langhe hills are shaped mostly in the form of cuestas (Biancotti, 1998). The drainage system is made of main monoclinal valleys, flowing into the Tanaro nearby Asti and Alessandria plains, and secondary cataclinal and anaclinal valleys.

The present Langhe landscape results from a composite evolution outlined as follows according to Biancotti (1998).

Upper Pliocene – Lower Pleistocene:
formation of an erosion pediment plunging NW, under a mitigated tropical climate.

Lower Pleistocene – Upper Pleistocene:
transition to a temperate climate; formation of cataclinal main valleys feeding the Tanaro River, that up to this time was flowing into the Po south of Torino; cutting of the glacis residual surface; modelling of a cuesta relief; development of a rectangular river pattern.

Upper Pleistocene – Olocene:
gradual capture and NNE diversion of the above-said cataclinal streams, owing to the upstream erosion exerted by monoclinal rivers that were flowing into the Po River around Alessandria. Rejuvenation of the cuesta relief.

Among the fluvial piracies that took place in Langhe Hills, the most famous and studied are the ones that occurred in the Tanaro and Belbo basins. According to Carraro et al. (1995), the Tanaro River progressively migrated ENE after a period of evolution of a marginal structure of the Langhe (the Fossano Living Anticline). This determined a flattening of Cuneo plateaus and of the western edge of the hills, due to lateral erosion: migration continued until such times as a pre-existing incision was intercepted south of Bra, finally the river overflowed into it, taking on its current course.

2.2.2 Pleistocene plateaus

The complex of Pleistocene plateaus is made up of many types of relict landforms, such as erosional *glacis*, covered *glacis*, planation surfaces and river terraces, isolated and emerging from the main surface of the Po Plain (*livello fondamentale della pianura*) or slowly connected to it, downstream, to the hills upwards. According to their morphology four different groups of plateaus can be recognized.

Cuneo plateaus

The Cuneo plateaus are a cluster of stepped river terraces lying in the SE sector of Cuneo plain (area in active subsidence during the Pliocene and the Quaternary), above which they stand out as actual islands. The morphogenesis of these landforms is due to Pleistocene climatic changes and to the NNE diversion of the drainage system of this sector of the Po Plain, triggered by neo-tectonic movements that are still active to some extent (Biancotti, 1979). In the surveyed area only the eastern part of the terrace system, wedged between the rivers Tanaro (to the E) and Stura di Demonte (to the NW), is included. The terraces consist of Pleistocene deposits gradually joined to the west with the main surface of the Po Plain, otherwise suddenly connected to the present valley bottoms of Tanaro and Stura di Demonte rivers. To the east the Pleistocene plateaus are linked to Olocene terraces, suspended above the Tanaro river bed. As a consequence of the capture of the river Tanaro the whole terraces are cut by epigenetic streams that dug deep gorges in their distal sectors.

Poirino plateau

The Poirino plateau is made of two planation surfaces separated by the Rioverde stream that are connected to the north with the Torino Hill, to the east with the Asti hills, to the south and to the west with the Po Plain. The northern sector of this plateau is a river erosion-surface, shaped by an ancient collector of the Southern Piedmontese Basin ("paleo Po"), that alternated erosion and deposit as a consequence of tectonic mobility of the main structures of the area. During the Upper Pleistocene the combined effect of the northwards migration of the Asti Syncline and the fluvial aggradation on the northernmost edge of the Southern Piemonte Basin determined a migration of this paleoriver, that took on its present position (the Po River). The southern part of the plateau is the residual of a glacis plunging NW, connected to the SE with the Roero Hills, that can be correlated to Langhe pediment. During the Olocene the Porino plateau was cut down by the Banna and Meletta streams, that flow into the Po River south of Torino. Since the substratum of the Pleistocene deposits mostly shows a monoclinal structure (plunging NW in the southern sector, SW in the northern sector), the superimposed streams are shaping a relief in the form of "micro cuestas", which is especially clear in the Banna basin, where fluvial erosion is higher.

Alessandria plateaus

The Alessandria plateaus are a group of stepped river terraces lying in a circle around the subsiding Alessandria Basin and connected upwards with the easternmost part of the hills mentioned above. The fluvial terraces around Novi Ligure, that close to this SE the series of residual surfaces, are not included in the area of interest, bounded to the east by the rivers Orba and Bormida. The terraces are connected each other and with the valley bottoms by slopes whose height and steepness decrease going uphill and that tilt towards Alessandria plain. As said above about the Cuneo Plateaus, the terraces result both from climatic changes and geodynamic evolution: lateral uniformity of Alessandria plateaus indicates how here the balance between the two factors was higher than around Cuneo, where neo-tectonics is the main factor that determined geomorphogeny. Also the Alessandria plateaus are cut by epigenetic water streams that have dug deep canyons in some of the southernmost terraces.

Valenza Po plateau

The Valenza Po plateau is a strip of fluvial terraces connected to the SW with the Monferrato hills, to the NE with Casale Monferrato plain, with Pomaro Monferrato inselberg and with the bed of the Po river, that undermine the southern scarp of the table-land. This plateau is different from the above-said ones because of the following reasons:

- it is covered evenly by loess deposits, which are discontinuous, scarce or lacking in the terraces mentioned above;
- it is almost entirely made of Lower Pleistocene deposits, connected downwards with Olocene terraces or with present valley bottoms;
- it is carved by tributaries of the Po River flowing NE that have a drainage texture higher than that of the streams superimposed to the terraces around Cuneo and Alessandria;
- to the feet of the scarps enclosing the terraces a Pliocene substratum, exhumed by the recent intense fluvial erosion, often outcrops.

The genesis of these terraces is linked with neo-tectonic movements and with the dynamics of an ancient stream network whose relict valley bed is the plateau itself. Two hypothesis are suggested in order to explain the morphogenetic process:

- on the one hand, residual landforms might have been modelled by the Po River, which - in an ancient course, more or less parallel to the present one - flowed towards the axial zone of a syncline whose northern limb coincides to the Pomaro Monferrato relief;
- on the other hand, the genetic process could result from the diversion of the Dora Riparia River that until Upper Pleistocene was running SE through a portion of the present Val Cerrina (Carraro *et al.*, 1995), flowing into the paleo-Po between Valenza Po and Casale Monferrato.

Fig. 5 - A cuesta landscape in the Langhe monoclinal relief (Somano, Valle Rea). In the close-up of the image the crest of a front slope ("*versante a reggipoggio*"); in the center the structural surface of a back-slope ("*versante a franapoggio*"); the Rea stream flows (towards right in the image) between this lop-sided slopes into a likewise asymmetric lowland.

*Paesaggio a cuesta nel rilievo monoclinale delle Langhe (Somano, Valle Rea). In primo piano la sommità di un fronte monoclinale ("*versante a reggipoggio*"); al centro della foto la superficie strutturale di un rovescio monoclinale (*versante a franapoggio*); il torrente Rea scorre (verso destra nella foto) tra questi versanti disarmonici in una depressione monoclinale a sua volta asimmetrica.*

2.2.3 Main surface of the Po Plain and present high-water beds

The main surface of the Po Plain is a ground level made of alluvial fans, terraces and portions of *glacis* set down between Upper Pleistocene and Olocene. This surface is connected, gradually or abruptly, to the mountains, the hills, the Pleistocene plateaus or the present flood-plains. This geomorphological unit is made up of two areas corresponding to distinct drainage channels:

- in the first the Po stream network runs down flowing through the "Torino corridor", a structural depression between Alps and Apennines;
- the second is the outlet of Tanaro river system, that feeds the Po River in the Alessandria Basin, a structural depression between the Monferrato and the Ligurian section of the Apennines.

The watershed of these two basins lies between the Grana-Mellea and the Stura di Demonte rivers in the south-western sector of the Po Plain and goes on NE through Roero hills, Poirino plateau, Torino Hill and Monferrato hills.

The Po basin

In the surveyed area the first drainage system is represented solely by the riverbed between Moncalieri and the mouth of Tanaro River and by limited parts of nearby Olocene terraces. In this section the Po River is antecedent to the uplifting hills of the "Monferrato arc": thus the river has partly incised the alluvial fans of its main left tributaries and has undercut the hills on its right bank.

The Tanaro basin

The Tanaro stream network runs into well developed valleys deepened into the south-eastern hills of the area. The Tanaro River, starting from its valley outlet, encircles the Langhe hills to the SW, flowing SSE-NNW. South of Bra, due to the effect of the aforementioned capture, it bends to NE touching one after the other the north-westernmost back-slop of the Langhe monoclinal and the south-easternmost front slope of the Roero monoclinal. Once in the Asti hollow, the river firstly turns to the SE, adjusting its bed to the axial direction of the Asti Syncline, lastly bends eastwards, up to the confluence with the Po River.

These two river basins differ, besides from their patterns, from their longitudinal profiles: while the Po River and its tributaries mostly flow at the same altitude of the main surface of the plain or are just slightly embedded in it, the Tanaro stream network is definitely intrenched into this ideal reference level and deepens the relieves it runs through. Such a morphologic (and hydrologic) diversity is a consequence of the evolution expounded above and it should result in further changes in the two rivers systems, due to the different relief energy of the two areas.

3. THE GEOMORPHOSITE INVENTORY

3.1 Methodology

In order to identify natural assets in a region such complex as the one delineated above, geologically, geomorphologically and scenically heterogeneous and very wide (the surveyed area has a surface of 4500 km^2), the inventory of geomorphosites had to be based on a clearly defined methodological process.

Each of the acknowledged geomorphological units is characterized by a limited number of main landforms and processes, arranged and repeated systematically in circumscribed areas (corresponding to the distinct landscape units defined above). In order to select in each of these geosystems the geomorphological sites emblematic of their evolution, it was therefore necessary firstly to identify the geomorphological objects (limited landforms, wide sites and even particular landscapes) that were essential to "read" Earth's History, secondly to gather among them a representative sample of comparable features.

The first stages of the process were the study of both scientific and popular bibliography, archive searches and the analysis of topographical, geological and geomorphological cartography. The documents allowed a selection and a preliminary classification of the sites and they were useful as an essential support material both for the description and for the evaluation of geomorphological objects.

The second work phase was a detailed survey that resulted in the exploration of those areas considered the most representative for the geodiversity of the territory. The direct observation of landforms and processes led to produce unpublished information (images, morphometrical measures, geomorphological maps) and to acquire new elements for assessment. The field research was combined with the analysis of aerial photos and satellite images. These tools were worthwhile only in order to spot geomorphological units or structural elements, while the location of landforms by remote sensing was usually prevented or hindered by the thick cover of vegetation and by the density of human settlements.

As a support for the survey a card (Costamagna, 2002), analogous to that proposed in 2000 by the Italian National Geological Survey, was used. This form (Fig. 7), structured as a database, is made of fields where three sets of data (descriptive parameters, criteria useful for assessment, right to use of Natural assets; refer to Table 1), concerning geosites and their environment, are inserted.

The information acquired on the field have been recorded in a database built in an Access® environment, which digitally mirrors the terrain files and guarantees the following advantages:

- it allows to organize data in a methodical way and to eliminate repetitions;
- it makes queries and information finding much easier;
- it helps the production of documents and iconographic material;
- it creates the basis for building a Geographic Information System (G.I.S.) for geosites.

The observations performed and the documents surveyed have allowed for a classification and a first-hand evaluation of all recorded geomorphological elements. According to archived data, and by theoretically revising the evaluations made during field activity, the scientific value of the sites have been assessed.

Tab. 1 - Parameters of the form proposed in 2000 by the Italian National Geological Survey for the survey of geosites.
Parametri delle schede per il rilevamento dei geositi proposte nel 2000 dal Servizio Geologico Nazionale.

Description	Identification codes; name of the geosite; location (Region, Province, District, Placename); coordinates; height; cartographical references; synthetic description; list and explanation of acquired images; geological data; geomorphological data; main scientific interest.
Assessment	Value of main scientific interest (rare, exemplar, representative); importance of main scientific interest (local, regional, national, international); further reasons for interest (scientific, cultural, socio-economic, educational, scenic); inclusion into a preserved area (according to Italian Law No 394/1991); existence of other territorial bonds; state of conservation; evaluation of natural and human hazards; degree of subjectivity of all the expressed opinions.
Right to use	Accessibility by foot or by other means; topographical position (surfaced, submerged, underground); type of property (public or private); distance from: drinking water, areas with facilities, camping, hotels; soil use (cultivated, non-cultivated, terraced, outcropping rock); visibility and scenic quality; season suggested for visiting; comments and notes of the Author of the inventory.

Tab. 2 - Description of the four categories in which the selected geomorphological objects were classified (according to Grandgirard, 1995; 1996).
Descrizione delle quattro categorie in cui sono stati classificati gli oggetti geomorfologici selezionati (in accordo con Grandgirard, 1995; 1996).

Isolated landforms	Sets of landforms	Complexes of landforms	Geomorphological systems
They are the basic features of the physical landscape resulting from the activity of one dominating	They present only one type of landforms that result from the activity of one dominating process and thus are usually concentrated on the same area.	They result from the activity of one dominating process but present many types of landforms.	They are important concentrations of polygenic and polycyclic landforms, resulting from many different processes interacting on the same area.

3.2 Assessment of Geomorphosites

In order to evaluate the scientific importance of the surveyed gemorphological objects it seemed useful to choose a method that allowed to asses their relative value, to reckon their "specific weight" and to draw quick comparisons among heterogeneous landforms. To these purposes, the process provided by the Italian Geological Survey seemed to be incomplete, since it does not systematically take into account all parameters necessary for a selection of geosites, and it does not contemplate the formulation of quantitative assessment. Therefore, in these forms the items concerned with scientific and environment value of Geosites were used to express a synthetic qualitative evaluation.

In order to reduce subjectivity to a minimum the method conceived by Grandgirard (1995; 1996) was applied.

Following this method, a mode of categorization was adopted, based on a classification that arranges landforms according to the geomorphological process recognized as responsible of their genesis. Thus led to classify geomorphological objects in four categories of increasing complexity (refer to Table 2).

The scientific value of the sites was reckoned assessing six fundamental criteria called Factors (refer to Table 3).

"Integrity" (I) is due to the degree of preservation of the original characteristics of isolated landforms when compared to an ideal model and related to human intervention.

"Representativeness and exemplarity" (RE) are a function of didactic value and "readability" of the observed phenomena and are graded differently for each category of geomorphological objects.

"Rarity" (R) is related to an area of reference (the surveyed area in this specific case) and it can be due to some exceptional characteristics of geosites, according to whose a geomorphological object can be assessed as rare even if it belongs to a type of landforms not particularly rare.

Tab. 3 - List of the Factors and examples of Indicators used to assess the scientific value of geomorphological objects.
Elenco dei Fattori ed esempi di Indicatori usati per assegnare una valenza scientifica ai siti.

Fundamental criteria (Factors)	Secondary criteria (Indicators)
Integrity (I) *Representativeness, exemplarity (RE)* *Rarity (R)* *Paleogeographic value (PV)* *Bibliographic significance (BS)* *Geosites included/including (GI)*	*Dimensions, geometric configuration, age, functional disturbance, morphogenic activity context, environment, geodiversity, scenic value, further reasons for interest …*

"Palaeogeographic value" (PV) is an index of the importance of a geosite as a "witness" of Earth's History, i.e. local climatic, ecological, geomorphological and geological evolution.

"Bibliographical significance" (BS) gives an added value to those sites that have been or are the subject of scientific research.

The existence of "geosites included" (GI) leads to assess an additional value to those geomorphological objects encompassing (or encompassed by) other geosites (e.g.: a complex of landforms in which one or many isolated morphological sculptures can be considered geosites themselves).

The Factors were assessed by using several secondary criteria (Indicators, refer to Table 1), graded differently for each morphological category. According to the described process, a score was assigned to the Factors in a very simple scale: 0 = no value; 1 = low value; 2 = medium value; 3 = high value. The total "weight" of each geosite results from the sum of the values assigned to the factors, expressed as a percentage index referred to the highest result that could be obtained: in this way a scientific value is given to geomorphological objects and a comparison among analogous sets of landforms or morphological categories can be drawn. As an example the evaluation of eight complexes of landforms of the Roero Hills is presented (refer to Table 4). These geomorphological objects, that are also locally known as "*Rocche del Roero*" ("Rocks" of the Roero Hills), are ravines, "earth pillars" (refer to Fig. 6) and river erosion slopes. Though common in many areas of the Asti Hills they are emblematic for the above-said watershed between the Po and Tanaro basins.

Moreover, for each of the assessed factors a synthetic estimate was written in order to make easier the geosite selection, that involves to compare heterogeneous parts of he landscape. As an example the explanatory notes concerning the complex of landforms selected as a geosite (the "*Rocche di Pocapaglia*"; refer to Fig. 6) among the above-said ones are presented (refer to table 5).

3.3 Selection of Geomorphosites

By using these procedures, a list of geosites that marks out geomorphological evolution of the area was drawn. These sites have a special landscape-related importance and can be considered geomorphological assets, due to their scientific value.

At present, 29 geosites have been selected, all in the S and NW sectors of the surveyed area, then classified (refer to Table 6) according to the "Grandgirard's method" (1995; 1996). This list is temporary, as the assessment of Geomorphosites in the central and north-eastern areas is still in progress.

Each of the Geomorphosites categories was graded according to the process (either external or internal) that is prominent in the morphogenesis, shortened as follows: A = aeolian; F = fluvial; G = gravitative; K = karstic; S = structural.

Fig. 6 - A set of earth pillars, that are some of the geomorphological objects in the complex of river-erosion landforms of the "Rocche di Pocapaglia".

Piramidi di terra, uno degli elementi morfologici nel complesso di forme d'erosione fluviali delle "Rocche di Pocapaglia".

Tab. 4 - An example of Geomorphosites assessment: complexes of river-erosion landforms of the Roero Hills ("*Rocche del Roero*"). Scientific value (SV) is couched in two ways: combined score (P) = I + RE + R + PV + BS + GI; per cent index (PI) = P/18.

Esempio di valutazione di geomorfositi: complessi di forme d'erosione fluviale ("Rocche del Roero"*). La valenza scientifica (SV) è indicata in due modi: punteggio cumulato (P) = I + RE + R + PV + BS + GI; indice percentuale (PI) = P/18.*

	Factors						SV	
Place-name	I	RE	R	PV	BS	GI	**P**	**PI**
1-Pocapaglia	3	3	1	2	3	3	**15**	**0,83**
2-Sommaria Perno	1	2	1	2	1	1	**8**	**0,44**
3-Baldissero d'Alba	2	1	1	2	0	2	**8**	**0,44**
4-Montaldo Roero	2	2	1	1	0	3	**9**	**0,50**
5-Monteu Roero	1	2	1	1	0	2	**7**	**0,39**
6-S. Stefano Roero	2	1	1	1	1	2	**8**	**0,44**
7-Montà	2	2	1	3	2	2	**12**	**0,67**
8-Cisterna d'Asti	1	2	1	2	1	2	**9**	**0,50**

Tab. 5 - Explanatory notes expressed for assessing factors concerning the "Rocche di Pocapaglia" (site N. 1 in table 4).

Giudizi esplicativi formulati per i fattori usati nella valutazione delle Rocche di Pocapaglia (sito N. 1 nella tabella 4).

Factor	**Note and assessed value [n]**
I	Isolated landforms that made up this morphological complex are well preserved. Rare traces of human impact (paths, galleries) exist, that are merged into the landscape and create a sort of local historical and cultural heritage themselves. [3]
RE	This complex of landforms is the most representative (quantity-, dimension-, geometry-wise) and the most emblematic (landscape- and availability-wise) in order to "read" both inactive and active processes that have shaped the Roero Hills [3]
R	This geosites are ordinary and endemic in the Asti Hills morphological unit, not very well-spread in the rest of the surveyed area [1]
PV	This geosite is not far from the River Tanaro "piracy point" and is surrounded by a lot of relict landforms. Thus, it is a good witness of the geomorphological evolution of the landscape [2]
BS	The "Rocche di Pocapaglia" have been the subject of thorough studies that highlighted their scientific importance and paved the way for exploitation of the whole "Rocche" area, long since part of preservation and landscape promotion projects [3]
GI	The geomorphological sculptures that form this complex cannot be considered isolated geosites. The "Rocche" of the Roero Hills are close to other geosites, different in nature: sedimentological, palaeonthological, stratigraphical [3]

Geomorphological systems (g. s.) are marked with a progressive Roman numeral (I, II,…): in each of those who have been selected, the main genetic factor is structure, the secondary morphogenetic agents are mass movements and river erosion.

Complexes of landforms (c. l.) are ordered according to a capital letter symbolizing the dominant process, followed by a progressive Arabic numeral.

Sets of landforms (s. l.) and isolated landforms (i. l.) are classified likewise the complexes of landforms, with the addition of small letters, standing for the name of every morphological sculpture, as follows: ag = anticlinal gap; av = anticlinal valley; bl = badlands; ca = cave; fes = fluvial erosion saddle; fm = "fossil" meander; go = gorge; ld = loëss deposits; ls = landslide scar; mwc = mean water channel; res = river erosion scarp; fs = fault slope; ssw = structural surface witness; fav = flat bottom abandoned valley.

In order to obtain a graphic plainness, Geomorphosites, identified by progressive numerals (ID), are displayed (refer to Fig. 1) as dots corresponding to single landforms or to the hub of the areas containing sets and complex of landforms and geomorphological systems.

For every selected Geomorphosite, gathered data have been processed and two documents have been drawn, following the model proposed by Italian S.G.N. (refer to Fig. 7 and 8):

- a main card, comprising the identification codes and those data, acknowledged on a national level, defined as "the minimum required content for a geosite inventory";
- a secondary form where subjective opinions of the Author and additional information, concerning environmental context, accessibility, right to use, need for preservation and chances for exploitation of the geological heritage, are reported.

As an example the descriptive card concerning the Geomorphosite N. 1 ("Grotta nei gessi di *Monticello d'Alba*") is shown (refer to Fig. 7). This is the sole practicable cave into Messinian gypsum in the Piemonte Region and up to now it is the only karst geosite included in the inventory. Taking into account the qualitative ranking coming from the present database, this geomorphosites has been graded as an asset of national importance, due to its rarity, its paleogeographic value and its bibliographic significance.

All these documents, along with the original images, will be sent to the Italian National Geological Survey so that the Geomorphosites mentioned could be added to the "Database of Italian Geological Assets". Under a practical point of view, the above-said forms can turn out to be useful in many fields:

- as a tool for scientific research, since they describe type-places of a landscape, they summarize the bibliography and they pave the way for new study projects;
- in the field of exploitation of natural assets, since they provide essential elements to create didactic papers and to promote educational activities, due to the fact that they give a simplified interpretation of the evolution of a territory and of its geomorphological wealth;
- in the frame of land-use planning, since they represent a reliable and easy-to-read source in order to assess environmental impact, to enhance sustainable

SCHEDA SPERIMENTALE PER L'INVENTARIO DEI GEOSITI ITALIANI

INVENTARIO DI GEOMORFOSITI DEL PIEMONTE CENTRALE (ITALIA NW)

IDENTIFICATIVO SCHEDA

Codice	Autore/i	Acquisizione Dati	Data	Scheda Associata
1	A. Costamagna	Rilevamento, Bibliografia	2001	

GROTTA NEI GESSI DI MONTICELLO D'ALBA

UBICAZIONE		COORDINATE U. T. M. (Zona 32 T)					
Regione	Piemonte	**Est (m)**		417487			
Provincia	Cuneo	**Nord (m)**		4951510			
Comune	Monticello d'Alba	**QUOTA (m s.l.m.)**					
Toponimo/Località		**Massima**	208	**Minima**	203	**Media**	205

RIFERIMENTI CARTOGRAFICI

Tipo	N° Carta	Denominazione	Scala
C.T.R.	192080	Monticello d'Alba	1 : 10 000

INTERESSE SCIENTIFICO PRIMARIO

Categoria	Geomorfologico	**Valutazione**	Raro	**Grado**	Nazionale

INTERESSE SCIENTIFICO SECONDARIO

Geominerario, Mineralogico, Stratigrafico, Sedimentologico

ALTRI TIPI D'INTERESSE

Primario	Speleologico	**Secondario**	Storico; didattico

VALUTAZIONE DEL GIUDIZIO ESPRESSO

Oggettivo. La grotta è un esempio di carsismo nei gessi unico a livello regionale, raro a livello nazionale. L'importanza del sito si può desumere dall'analisi dei documenti bibliografici citati.

DESCRIZIONE

La grotta è un'insieme cunicoli carsici a prevalente sviluppo orizzontale, scavati in lenti di gesso cristallino ($CaSO_4 \cdot 2H_2O$) che, intercalate a marne e marne argillose, costituiscono il versante orografico destro del torrente Mellea (affluente di sinistra del fiume Tanaro). L'antro costituito da molteplici cavità comunicanti, impostate lungo diaclasi a prevalente direzione Nord-Sud. Le gallerie presentano morfologia sia vadosa (cunicoli stretti e alti), che freatica (soffitti piatti coincidenti con livelli marnosi). In entrambi i casi è evidente il sistema di fratture che ha influenzato lo sviluppo dei cunicoli. La grotta è caratterizzata dall'abbondanza di sedimenti, in prevalenza marnosi e a granulometria variabile (dalle argille ai blocchi). Essi sono in parte alluvionali, in parte derivano da crolli di materiale dall'alto. I frequenti massi che ostruiscono il percorso, la scarsità di tratti di pavimento orizzontale e la difficile identificazione della direzione di scorrimento dell'acqua fanno supporre che l'attività idrica recente sia stata minima e che prevalga quella gravitativa. Anche lo stillicidio dall'alto pare essere ostacolato dalla presenza di marne argillose al tetto della Formazione gessoso-solfifera. Le cavità sono scavate in banchi di gesso balatino, fittamente stratificato in lamine millimetriche sub-orizzontali; meno di frequente si rilevano blocchi di selenite, costituiti da grossi cristalli singoli o geminati, e geodi. Fra i riempimenti della grotta esistono cristallizzazioni di cinabro (HgS) e di epsomite ($MgSO_4 \cdot 7H_2O$), minerale che si presenta come efflorescenze sul pavimento delle gallerie a forma di sottili aghi fragili e deliquescenti. Vanno citati inoltre i depositi di guano di pipistrello: fino a pochi anni fa la cavità ospitava ricche colonie di questo animale. L'accesso alla grotta, già nota per la presenza di un cunicolo nel fianco NE della collina a sud di Monticello, è oggi possibile attraverso sette aperture messe in luce dai lavori di coltivazione di una cava di gesso in sotterraneo.

ELEMENTI GEOLOGICI E MORFOLOGICI CARATTERIZZANTI

Litologia	Lenti di gesso intercalate a marne e marne argillose per lo più gessifere
Unità Cronostratigrafica	Formazione gessoso-solfifera (Messiniano)
Età del processo genetico	Pliocene medio - Attuale

Tipologia	Forma singola	**Estensione**	Lineare	**Esposizione**	Antropica
Lunghezza (m)	658	**Area (m^2)**		**Spessore (m)**	

Fig. 7 - Example of a descriptive card corresponding to the model proposed by S. G. N. for the inventory of Italian geosites.
Esempio di scheda descrittiva conforme al modello proposto dal Servizio Geologico per l'inventario dei geositi italiani.

Tab. 6 - List of selected geomorphosites. Category: g.s. = geomorphological system; c.l. = complex of landforms; s.l. = set of landforms; i.l. = isolated landforms. Mark: see section 3.3 for the explanation. ID = identification code (refer to Fig. 1).

Elenco dei geomorfositi selezionati. Categoria: s.g. = sistema geomorfologico; c.f. = complesso di forme; i.f. = insiemi di forme; f.i. = forma isolata. Sigla (Mark): vedere il paragrafo 3.3 per la spiegazione. ID = codice identificativo (cfr. Fig. 1).

Category	Mark	Geomorphosite Name	ID
g. s. (*s. g.*)	**I**	*Cuesta* of La Morra (*Cuesta di La Morra*)	**6**
	II	*Cuestas* of Rea Valley (*Cuestas della Valle Rea*)	**12**
	III	Peak of Guarene d'Alba (*Superficie sommitale di Guarene d'Alba*)	**16**
	IV	*Micro-cuestas* of Poirino Plateau (*Microcuestas dell'Altopiano di Poirino*)	**19**
	V	Ridge of La Maddalena (*Dorsale della Maddalena*)	**25**
c. l. (*c. f.*)	**F 01**	"Rocks" of Pocapaglia (*Rocche di Pocapaglia*)	**2**
	F 02	Terraces of Bene Vagienna (*Terrazzi di Bene Vagienna*)	**8**
	F 03	Terraces, meanders and ox-bows of Fellizano (*Terrazzi, meandri e lanche di Fellizzano*)	**27**
	F 04	Terraces of Alessandria (*Terrazzi di Alessandria*)	**28**
	F 05	Anticlinal valley and cataclinal gully of San Genesio (*Comba e rû di S. Genesio*)	**21**
	G 01	Gravitational phenomena of Albugnano (*Fenomeni gravitativi di Albugnano*)	**20**
s. l. (*i. f.*)	**A ld 01**	Loëss deposits of Trofarello (*Depositi di loëss di Trofarello*)	**26**
	F fes 01	Saddles of Bossolasco (*Selle di Bossolasco*)	**13**
	F bl 01	Badlands of Alba (*Calanchi d'Alba*)	**14**
	F bl 02	Badlands of Treiso (*Calanchi di Treiso*)	**15**
	F res 01	"Rock" of Salmour (*Rocca di Salmour*)	**10**
	S fs 01	Fault slopes of Cascina Fagliaverde (*Scarpate di faglia di Cascina Fagliaverde*)	**18**
i. l. (*f. i.*)	**C gr 01**	Cave in the gypsum of Monticello d'Alba (*Grotta nei gessi di Monticello d'Alba*)	**1**
	F ag 01	Anticlinal gap of Gassino (*Chiusa di Gassino*)	**23**
	F av 01	Anticlinal valley of Rivalba (*Comba anticlinale di Rivalba*)	**22**
	F fav 01	Abandoned Tanaro Valley (*Valle relitta del fiume Tanaro*)	**3**
	F fm 01	"Fossil" meander of Chieri (*Meandro relitto di Chieri*)	**24**
	F go 01	Epigenetic gorge in the Cherasco Plateau (*Gola epigenetica nel terrazzo di Cherasco*)	**7**
	F go 02	Gorge of the river Mondalavia (*Forra del Rio Mondalavia*)	**9**
	F go 03	Gorge of Carpeneto (*Forra di Carpeneto*)	**29**
	F mwc 01	Tanaro riverbed by Cherasco (*Alveo del fiume Tanaro a Cherasco*)	**4**
	F mwc 02	Stura di Demonte riverbed by Salmour (*Alveo del fiume Stura di Demonte a Salmour*)	**11**
	G ls 01	"Rock" of Vezza d'Alba (*Rocca di Vezza d'Alba*)	**17**
	S ssw 01	Monadnock of Pollenzo (*Rilievo isolato di Pollenzo)*	**5**

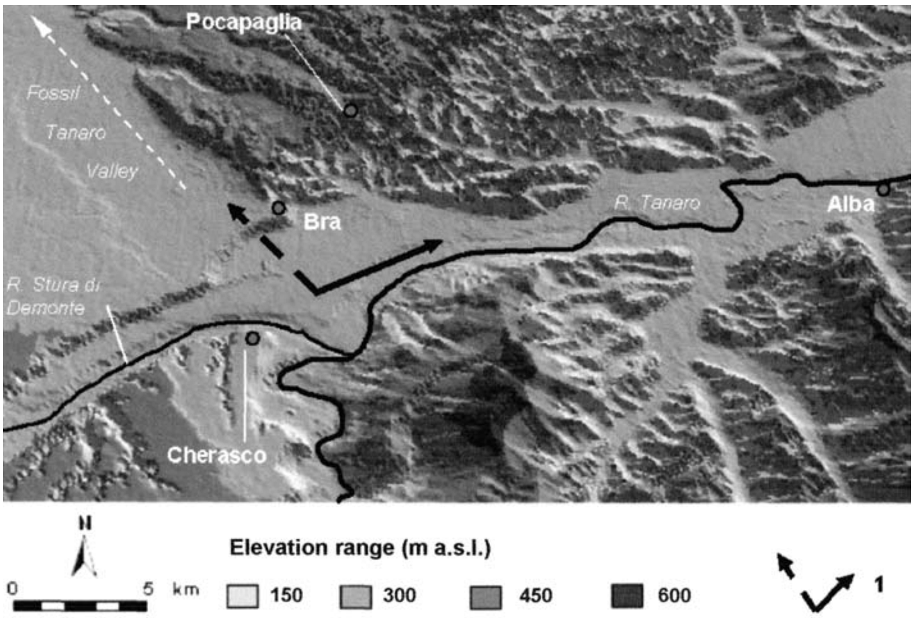

Fig. 8 - Digital Terrain Model of the "piracy point" (1) of Tanaro River (the white arrow shows the axis of the abandoned valley). This area is deepened by the entrenched Tanaro stream network. The following landscape units are represented: the Roero "negative hills", NE and E of Pocapaglia; the Langhe cuesta, S and SW of Alba; the terraces of the Cuneo Plain, S of Cherasco; the Poirino Plateau and the Tanaro fossil valley, N and NW of Bra.

Modello altimetrico tridimensionale della zona di cattura (1) del fiume Tanaro (la freccia bianca indica l'asse della valle abbandonata). *Quest'area è incisa dai fondovalle incassati del Tanaro e degli affluenti. Si osservano le seguenti unità geomorfologiche: a NE ed E di Pocapaglia il sistema di "colline negative" del Roero; a S e a SW di Alba la cuesta delle Langhe; a S di Cherasco i terrazzi fluviali della pianura di Cuneo; a N e a NW di Bra l'altopiano di Poirino e la valle abbandonata dal Tanaro.*

economic development and to promote the conservation of a healthy environment.

4. CONCLUSIONS

The study case exposed consists in surveying Geomorphosites in a sector of the Piemonte Region that is especially sensitive under a geological and geomorphological point of view, due to human impact, to the relative lack of protected areas and to the endemic negative effect of environmental dynamics that culminate in recurring "hydrogeological hazards".

The comprehension of the Earth's History by "reading" accessible and clear "witnesses" which mark out the geomorphological wealth of a region, which show its genesis and which forecast its possible evolution is a fundamental goal in the frame of sustainable land-use planning and management.

The assertion of the geosite concept and the need of exploitation and preservation of natural resources have to be shared by researchers, local communities and potential users of geological assets (e.g. the "geo-tourists").

The issues presented above, though preliminary, aim to be an actual contribution in order to start out the process of promotion, exploitation and protection of regional Geological Heritage and to awaken public opinion to environmental problems.

Aiming to achieve these targets the realization of an inventory of Geosites is an essential instrument, but it is the cooperation between research institutions and local authorities that creates the ideal starting line to apply and spread this knowledge.

Thus, even if this study was not completed yet, some remarks upon the geomorphological wealth of the central Piemonte allowed to suggest to the holding company of Parks and Natural Reserves of Asti to bring on the sustainable exploitation in the area around the "piracy point" of the Tanaro River (refer to Fig. 8). Furthermore, due to its geodiversity, its palaeogeographical importance and its educational value, in this territory, that encompasses also archaeological, ecological and cultural assets and protected areas, the institution of a "UNESCO Geopark" (Eder & Patzak, 1999) should be proposed.

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