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## CONTENTS



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# GEOPARKS, GEOHERITAGE AND GEOTOURISM: OPPORTUNITIES AND TOOLS IN SUSTAINABLE DEVELOPMENT OF THE TERRITORY

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This special issue focuses on the three main concepts that can represent an important opportunity of growth and sustainable development for a specific territory or area: geoparks, geoheritage and geotourism.

In particular, we mean for *Geoheritage* a generic but descriptive term applied to sites or areas of geologic features with significant scientific, educational, cultural, or aesthetic value. In some zones of the Earth the geoheritage is particular important and it is concentred in a limited protected geographical area, the *Geoparks*, where geological heritage sites are part of a holistic concept of protection, education and sustainable development. These sites represent for the local community, directly, but also for all the society, an added value that can increase and improve the local economy, using the synergy between geodiversity, biodiversity and culture, in addition to both tangible and non-tangible heritage.

All the above cited concepts are directly linked to the *Geotourism*, defined as "*tourism that sustains or enhances the geographical character of a place, its environment, culture, aesthetics, heritage, and the well-being of its residents*". This concept was introduced in a 2003 report by the Travel Industry Association of America and National Geographic (Traveler magazine) and successively adopted by Hose (2012). Geotourism adds to sustainability principles a geographical character, the "sense of place" (Hose, 2012), to emphasize the distinctiveness of its place and benefit visitor and resident alike, such the case proposed by Lazzari (2013).

To facilitate public interest in geotourism, geoscientists, government agencies, communities, and other stakeholders must collaborate to sensitize the public, develop, and preserve these national patrimony/heritage sites for teaching, training, research, sustainable development, job creation, environmental conservation, and exploration of alternatives to traditional exploitation/uses.

This special issue has been realized in continuity with the activities of the 12th European Geoparks Conference (presence of 400 delegates from 41 countries from 5 continents), held on 4 - 7 September 2013 in the National Park of Cilento, Vallo di Diano and Alburni Geopark, which highlighted the strategies developed by the European and Global Geoparks Networks to promote an understanding of geohazards and the sustainable use of natural resources.

The title of the conference, "*Geoparks an innovative approach to raise public awareness about geohazards, climate change and sustainable use of our natural resources*" has been chosen to address the aims of the conference:

1. To verify how Geoparks can disseminate the scientific knowledge of the academic community concerning these issues;
2. To understand how Geoparks address these issues in the educational system;
3. To promote the role of Geoparks on the public awareness and sustainable use of natural resources.

The papers selected for this special issue discuss the topic from a methodological a point of view (Geodiversity as a new quantitative index for natural protected areas) or take into account some particular sites of Italy, such as the coastal cliffs of Capo Caccia in north-western Sardinia, the natural and cultural heritage in the landscape of the Carignano wine district of the Sulcis region (SW Sardinia) and the Abruzzo, Lazio and Molise National Park (central Italy) with example of Mount Greco and Chiarano valley.

The contents of this issue certainly do not exhaust a so wide and complex topic, but they can provide a direction of virtuous studies and researches, of which the communities and the areas, described in the papers, have benefited.

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# LOCAL AGRICULTURAL PRODUCTS IN TOURISM: A. J. STRUTT'S ACCOUNT OF SICILIAN PRICKLY PEARS

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**Abstract:** In the marketing of tourist locations several strands can be exploited to stress the potentialities of a place: landscape, buildings, quality foods. European regulations connect local food to the place and to history in terms of growing or manufacturing praxis and of local traditions rooted in ways of preparing and of consuming it. In tourism, food products add to the travel experience since they can be employed to define the cultural identity of a location. This paper, while reckoning the role of quality local food products in tourism, wants to call attention to the added value British grand tourists' reports can play in defining the historical roots of quality food items. To this aim, the brief descriptions of Sicilian prickly pears from Arthur John Strutt, a British painter and a traveller, are reported, and discussed for the first time, as a means to better characterize the PDO cactus fruits grown in Sicily.

**Key words:** Sicilian prickly pears, cultural capital, Grand Tour, British travellers, Arthur John Strutt.

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## INTRODUCTION

In tourism studies, the consumption of food during the holiday is increasingly seen as a strategic element in the marketing of a destination since local quality products add to the travel experience. Local products, in fact, are an important asset to define and to embody the social and gastronomic peculiarities of a place and are considered part of the cultural capital representing the expression of a country, of its society, and of its history (Bessière, 1998; Mak et al., 2012; Tregear et al., 2007).

The expression "*cultural capital*" is an umbrella term covering different strands that shape the identity of a location, namely landscape, i.e. rivers, lakes, mountains; historic buildings, i.e. churches, villas, archaeological sites; local traditions, i.e. customs, folklore, crafts, festivals; and local foods, i.e. ways of preparing and of consuming food items linked to a given territory (Bessière, 1998;

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Garrod et al., 2006). These different layers are at the base of those forms of tourism labelled under the rubrics of rural tourism, heritage tourism and gastronomic tourism (Richards, 2002; Sims, 2009).

The link between local products of agricultural or of animal origin and the peculiar traits of a geographical region is facilitated by the European Community (EC) characterization scheme known under the PDO/PGI/TSG labelling system. This classification of local quality food aims at stressing the products' qualities and the specific production standards connected to local praxis in terms of expertise and of local traditions.

The PDO label (Protected Designation of Origin) describes the specifications of those products that must be produced, processed and prepared within a particular geographical environment and with qualities or characteristics exclusive to that area, natural and human factors included; the PGI label (Protected Geographical Indication) describes those products bearing the name of a particular geographical area where the products' characteristics are attributable to that same area; the TSG label (Traditional Specialty Guaranteed) defines the traditional character of foodstuffs or agricultural products by its composition or by its production method (EEC Regulation No 510/2006).

These characterization schemes can be exploited in tourism to define local foods as iconic products that serve to stress the cultural identity of a place, thus adding up to the cultural experience of the travel (Bowen & De Master, 2011; Mak et al., 2012; Sims, 2010). Along this research line, several local quality products from different European countries are listed in the EC website devoted to foods with PDO, PGI and TSG trademarks (DOOR Website), while some products have been described by an historical point of view. Cases in point of the latter type can be considered the papers on *Culatello di Zibello*, on the *Beacon Fell traditional Lancashire cheese* (Tregear et al., 2007), on *Parmesan Cheese* (de Roest & Menghi, 2000), on French (Bérard & Marchenay, 2006) and Polish cheeses (Bowen & De Master, 2011), on *Mortadella di Bologna* or on *Caciocavallo Cheese* (Cianflone, 2012; 2013).

These descriptions serve to typify local quality food and the cultural, gastronomic and manufacturing traditions of a locality, thus stressing how local praxis is rooted in historic ways of growing or of preserving typical agricultural products or food items of animal origin.

Among these studies, a research line that has received little attention concerns the role the literature written by foreign travellers, describing their errands along the Grand Tour circuit, can play in defining the historical link between local foods and the territory. The scope of this note is, therefore, to report preliminary results from ongoing research to delineate the historical roots of some iconic Sicilian food items found in British travel literature. To this aim, the prickly pear from San Cono, considered a typical Sicilian fruit, is matched to historical evidence found in the description from a nineteenth-century British traveller and painter: Arthur John Strutt.

The note is organized as follows: first the history of the growing of prickly pears in Sicily is sketched, together with reference to the specifications of Sicilian prickly pears; then, Strutt's brief description of Indian figs is reported for the first time; the concluding remarks stress the value of this narrative in tourism to characterize the Sicilian cactus fruits.

## PRICKLY PEARS IN SICILY

Prickly pears, also called Indian figs, belong to the *Cactaceae* family, an ecotype widely distributed in the Americas and now in other parts of the world, such as the Mediterranean basin and Australia. The fruit is a fleshy berry, varying in shape, size, and colour (red, white and yellow); the pulp has a consistent number of hard seeds (Piga, 2004). The fruit is rich in water. Water amounts vary since, depending on the cultivar and on the harvesting season, it may account up to 90% of the total fruit content; it is also rich in lipids, proteins, minerals, fibers and volatile components that affect the flavour (Piga, 2004).

The Spanish imported prickly pears in Europe from the American colonies at the end of 15th century (Russell & Felker, 1987). They were first cultivated in the Canary Islands, where plants were grown to extract a red dye from a cochineal insect hosted by the plant (Barbera et al., 1992). From these islands, specimens were exported as a botanical curiosity to other Mediterranean locations where they found favourable growing conditions (Barbera et al., 1992). In Sicily plants soon became naturalized because of the climate, and were grown in several parts of the island. As time went by cacti had a consistent share in the local agriculture of subsistence typical of the Mediterranean island, and were defined by local historians "*the blessing of Sicily*" (Barbera et al., 1992).

Since the fruit is rich in nutrients, Sicilian prickly pears were used not only for human consumption but were also used as forage, being the cladodes rich in water (Barbera et al., 1992). Apart from the edible use, prickly pears were important to exploit some marginal areas characterized by infertile, steep and rocky soils, where little else could be planted.

Since cacti need little water, when planted in open fields, they were intercropped with other botanical specimens like almonds, carobs and pistachio trees to face the typically Sicilian limited water availability (Barbera et al., 1992). Along the centuries, the peculiar features of this plant, and the benefit peasants gained from its cultivation, shaped the Sicilian landscape to the point that the presence of cacti was considered a typical agricultural trait of the Mediterranean island.

**Figure 1.** Fico d'India di San Cono logo
(Source: DOOR Website)

**Figure 2.** Fico d'India dell'Etna logo
(Source: DOOR Website)

The second half of the 19th century, thanks to agricultural and industrial improvements (e.g. the use of hydraulic pumps, the importance of steam navigation) saw a resurgence of cacti plantations (Barbera et al., 1992) to the point that by 1850's cacti ranked third, after olives and grapes, among the Sicilian crops (Barbera et al., 1992).

The commercial success was favoured by many factors: new plantations established in the areas around the cities of Palermo and Catania; the introduction of a multiple-row system; the use of a late flowering which allowed the fruits' production in the months of October and November, when fresh fruits were generally lacking on the Sicilian tables.

Early in the 20th century, the commercial importance of prickly pears declined in favour of citrus fruits. Recently this plant has witnessed a renewed agricultural interest, with attention paid to cacti growing and to the definition of strict product specifications. To this aim two geographically restricted growing areas in Sicily were awarded the PDO trademark and cactus fruits, labelled "*Fico d'India di San Cono*" and "*Fico d'India dell'Etna*", were given a specific logo and strict growing practices to be followed were delineated by Italian and European regulations.

The *San Cono* prickly pears are grown within a defined geographic area comprised within the provinces of Catania, Caltanissetta and Enna, or to be more precise in the municipalities of San Cono, San Michele di Ganzaria, Piazza Armerina and Mazzarino. This growing area is characterized by hills (ca. 200-600 meters high) and valleys with a specific micro-climate that confers fruits their organoleptic features and characteristics. These peculiar traits can be summarized as follows: big shape, especially when compared to other Sicilian cactus fruits; rind with stout colours, sweet aroma and sweet taste.

The *Fichi d'India d*ell'Etna, on the other hand, are grown in the province of Catania, or to be more precise within the municipalities of Bronte, Adrano, Biancavilla, Santa Maria di Licodia, Ragalna, Camporotondo, Belpasso and Paternò, that is an area in and around mount Etna.

Cacti are gathered late in August and, after a second flowering, in December. The former are defined as quality A, while the latter, usually called "*bastardoni*" in the Sicilian dialect, are defined quality B. Both types are sold either in wooden, cardboard or plastic boxes containing fruits of three colours, namely yellow, white and red. Each box must bear the collecting date and the typical PDO badge. The *San Cono* logo is characterized, as shown in Figure 1, by three light blue cactus fruits, each one bearing a white crown; beneath the fruits five blue stars and an picture of Sicily can be spotted. The trademark, *Fico d'India di San Cono* and the PDO trademark is depicted in green. The *Fico d'India dell'Etna* logo is characterized, as shown in Figure 1, by the image of mount Etna connected to the image of cactus cladodes sketched in light blue.

Indian figs are commonly consumed by Sicilians as fresh fruit; local recipes make use of cactus fruits in different ways. They are sun-dried to be eaten during the late winter months; they are boiled to make a syrup used in sweets and to produce a liqueur; they are employed to make jam (Barbera et al., 1992).

## ARTHUR JOHN STRUTT (1819- 1888)

Arthur John Strutt was the son of the painter Jacob George (Ouditt, 2013). The father was his mentor and under his supervision he specialized as a landscape painter. They both travelled in France and Switzerland and settled in Rome, where the former died. In 1838-39 Arthur started with a friend, William Jackson, his pedestrian tour of southern Italy. From this travel experience resulted several landscape etchings, that are now lost, and a book, *A pedestrian Tour in Calabria and Sicily*, published in 1842 (Di Matteo, 2008).

The idea of a tour in southern Italy on foot was very uncommon for the travelling standards of the time since a walking journey required physical strength and a fit body, which both travellers did not seem to be deficient in (Di Matteo, 2008). Although pedestrian tours were not common at that time, this type of journey met Strutt's interest in landscape and in the depiction of local peasants (Ouditt, 2013).

Walking, in fact, allowed the painter to get acquainted with the southern scenery and with the life-styles of southern Italians, as some prints available on the market show.

Once in Sicily, the two travellers had planned to visit the whole island. The goal was not reached in full since they run short of money and were forced to come back to Rome (Di Matteo, 2008).

The book reporting the Sicilian sojourn is in the form of letters sent to his family, with a few etchings of Sicilian characters. These sketches conform to the taste of the time: human figures are depicted as part of the landscape. An interesting detail in the drawing published in the 1842 edition is that some cacti in a vase can be found on the left corner of the folio, where two peasants are represented in the typical Sicilian costume of the time.

## STRUTT'S DESCRIPTION OF PRICKLY PEARS

Strutt and his travelling companion, the poet William Jackson, undertook a pedestrian tour from Rome to Sicily. This travel experience was reported in his travel book published several years later, in 1842, where the traveller's impression of the places, of buildings and local customs were recorded, together with reference to eating habits of southern Italy. Among these descriptions, the few sentences devoted to Indian figs can be of interest to add to the history of a plant that has given the Sicilian landscape a specific imprint.

Cacti seem to have attracted Strutt's attention as a painter and as a travel writer. Evidence is found in the drawings attached to his travel book, where, as discussed above, a vase with a little cactus plant is depicted. The painter's interest in this plant is not only limited to the pictorial representation of the same. In his travel report, in fact, some sentences are devoted to the description of cacti, and also, reference to his not liking these cactus fruits.

As concerns the description of the plant, he highlights the consistent presence within the Sicilian landscape:

> *... Instead of aloes, so much in vogue on the other side of the straits, the Indian fig forms here an impenetrable hedge to the vineyards, and the luxuriance of the vegetation.*
>
> (A pedestrian Tour, 252-3)

> *The plantation of cactus* [...] *present[s] a curious appearance: small footpaths traverse them in various directions, but to turn to the right or left is rendered quite impossible, by the formidable prickly briar these solid vegetable masses present.*
>
> (A pedestrian Tour, 339)

As concerns the fruit, the painter does not seem to be very fond of Indian figs, as the following sentence confirms:

> *I am learning to eat this entirely Sicilian fruit called the cactus, or Indian*

*fig; but cannot, as yet, comprehend the enthusiastic love of it, which enabled our friend C--- to eat seventy-four for his breakfast.*

(A pedestrian Tour, 339)

These descriptions of a plant that was known to the British audience as a decorative specimen, sometimes seen in hot-houses, is important for the history of cacti in Sicily.

The sentences quoted above, in fact, offer one of the earliest complete reference from a Briton to the *Opuntis Ficus Indica* under the Sicilian climate. It serves to corroborate what is already known of the agricultural praxis of cacti in nineteenth century Sicily. This reference can serve local food historians to stress the presence of Indian figs in the *San Cono* area and on mount Etna in the earlier decades of the nineteenth century.

## CONCLUSION

Local foods play an important role in shaping the travel experience since regional quality products are being considered a means to define the cultural identity of a location. This recognition at the EC level has led to several initiatives aimed at fostering heritage and territory-based linkages (Bowen & De Master, 2011; Tregear et al., 2007). At the local level, gastronomic products play the main role in local events such as gastronomic fairs and food-and-wine routes.

These initiatives serve to stress the link between the territory and the culinary habits and are used as a marketing strategy to promote a tourist location. An additional input to valorize local food specialties can be offered by direct evidence taken from travel books (Cianflone, 2012).

As shown in the case object of this paper, Sicilian cacti and the nineteenth century description by Strutt can be used in tourism to highlight the collective memory of a society (Bessière, 1998) in which evidence from British travellers may have a share. The historical proof discussed in this note for the first time, is important to define the roots of a product of agricultural origin, known and appreciated in the past as it is today.

**Aknowlegments**

Although both authors conceived and approved the final draft, E: Cianflone is responsible for the following sections: 1, 2, 4, 5; while G. Cardile is responsible for section 3.

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# THE IMPRESSIVE COASTAL CLIFFS OF CAPO CACCIA IN NORTH-WESTERN SARDINIA (ITALY). OUTLINES FOR LANDSLIDE RISK ASSESSMENT

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**Abstract**: The coast between Capo Caccia and Punta Giglio promontories in the north-west of Sardinia is characterized by high cliffs extended for more than 37 km. Here the cliffs are interrupted only by the beach of Porto Conte and small rocky coves. They are made almost entirely of Mesozoic limestone rocks, which generally give rise to high coasts with different contexts of development and risk. Only a short section in the northernmost portion is given by marly-clayey rocks of Triassic. They form a highly unstable cliff, due to the presence of interbedded gypsum. This coast is formed by the recent flooding of the bay of Porto Conte, because in the past it was a large karst valley. In fact, the landscape of this area is dominated by karst landforms and a dense underground hydrographic network. The most famous karst caves are located in the continental part but, recently, the submerged caves have become an attractive location for divers. Finally, it is clear that the whole cliff of Capo Caccia and Punta Giglio has undergone a rapid evolution, driven by intense fracturing of the limestone as well as the deep and dense karstic process. This rapid evolution is demonstrated by the numerous landslides occurred along the coast and the absence/scarcity of sea level notches. In order to identify areas at risk of landslides along this coast so impressive, moreover corresponding to a Marine Protected Area and in part to a Regional Park, was made a GIS-based map of geomorphological risk related to the instability of the cliff. Such map shows four classes of hazard determined by the detection of fractures recognized only along the face of the cliffs and landslide processes occurring along it.

Key words: Cliffed coast, Landslide Risk, GIS-based mapping, north-western Sardinia

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## INTRODUCTION

In the world high and rocky coasts often represent one of the most popular tourist destinations. For this reason, some stretches of rocky coasts are protected by

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specific institutions of safeguard (natural reserves, parks and recently geoparks). However, this coastal type is subject to the convergence of continental and marine processes, which could cause changes rather quickly. In order to prevent damage and loss of this natural heritage, as well as to establish best practices for conservation and sustainable use of marine and coastal area, an assessment of the main conditions of instability is required. These conditions were evaluated along the cliffs of Capo Caccia and Punta Giglio in north-western Sardinia (Figure 1), set in the homonymous Marine Natural Reserve and in the Regional Park of Porto Conte.


**Figure 1**. Location of the study area

**CLIFFS IN STUDY**

Along the coast of Alghero municipality in north-western Sardinia develops a coastline dominated by the presence of an impressive limestone cliff. It extends for more than 37 km, interrupted only by the Mugoni beach situated in the deep bay of Porto Conte (Figure 2a) and other small rocky coves. This bay is enclosed by the promontories of Capo Caccia and Punta Giglio, which jut out into the sea, to the west and to the east respectively, making the coastal outline very suggestive (Figure 2b). This outline in plan can be considered as a ria that is a dry valley formed in karst environment (Federici et al., 1999), and then progressively flooded by the sea during the last stage of the Pleistocene climate change (Ginesu, 2004). This evolution has been confirmed by numerous archaeological findings, which have allowed us to reconstruct the ancient shorelines of the bay (Carboni & Ginesu, 2006). For example, during the Neolithic (6.000 years b.p.) the bay was a large coastal lake closed by sandy ridges. Instead, at the time of the maximum emersion, owing to the wide diffusion of limestone, the landscape was modelled by karst processes, as well as by a dense underground water flow network, made up by conduits and caves. Such network did not allowed a real surface drainage network, as can be seen even today. In fact, the Nurra, that is the Coastal Geotectonic Region where the cliff in study is located, lacks virtually of true rivers, while along its coast are well known numerous limestone springs.

The cliff (Figure 2b) is mainly made of Mesozoic carbonate rocks, which are in the immediate hinterland in tectonic contact with the Palaeozoic crystalline basement that is extensively exhibited on the Argentiera massif. Such massif forms the northern boundary of the area. In particular, the eastern side of the promontory of Capo Caccia is mostly given by dolomitic limestone of the Lower Cretaceous, while the western side is formed of dolomitic limestone of the Jurassic (Cherchi et al., 2010). In the northern section of the same headland marl, clay and gypsum of the Middle Triassic outcrop on the cliff (Posenato, 2002). Instead, the coast of the promontory of Punta Giglio, further to the east of the former cape, is exclusively formed of dolomitic limestone of the Jurassic (Cherchi et al., 2010).

**Figure 2a**. The inner part of the bay of Porto Conte between Capo Caccia and Punta Giglio

**Figure 2b**. The long promontory of Capo Caccia characterized by a continuous cliff mainly formed of Mesozoic limestone

Both promontories are affected by large faults with prevailingly orientation N-S and E-W, this makes their rock mass particularly rough. However, the greater fragility is found in the section in which outcrop middle Triassic deposits, not only for the intrinsic geomechanical characteristics, but for the proximity to the faults zone, that distinguish the contact with the Palaeozoic basement.

The height of the cliff is highly variable in the investigated coast between 320 m at Punta Cristallo (Figure 3) where middle Triassic rocks outcrop, and 200 m in front of the islands of Piana and Foradada. Continuing the analysis along the headland, the cliff rises up to 250 m at Punta della Pegna and then around Capo Caccia reduces to only 100 m. On the eastern side of the head, at the mouth of the bay of Porto Conte, it is much lower with values of about 50-60 m, while into the bay it rapidly decrease markedly in height and slope. Finally, the cliff at Punta Giglio, which close the bay to the east, does not exceed 100 m. Further to the east towards Alghero, the coastline became rapidly low. In the bay of Porto Conte the shore platform gently slope into the sea and join the base of the cliff, contrarily on the cliff, outer of the bay, where the deeper isobaths rapidly reach the cliff.

According to the characteristics recognized inside the bay of Porto Conte the presence of a shore platform adjacent to the cliffs permit to classify them as the type A of Sunamura (1992). Instead, most of the cliffs, exposed to the west and hence out of the bay, show a vertical walls like to the plunging type of Sunamura (1992), which continue below the sea level up to an average depth of 20 m. Because of this depth, the origin of most of these cliffs is due to tectonics, instead the other ones is attributed to the modelling in continental environment that occurred during the last lowering of the sea level of the Pleistocene.

At the base of these cliffs, as can be observed in underwater surveys, there are blocks of limestone, sometimes of considerable size. These blocks confirm the various phenomena of falling and toppling occurred along the western cliff. Such phenomena are classified as single event, easily defined in its shape, or as a multitude of events, complex expression of a widespread instability. The rock falls and topples are favoured by both the considerable fracturing and the prevailing waves from NW.

However, the erosion of the cliff, rather than being imputed to the energy of waves, must be attributed to the effectiveness of the karst processes. Such processes are mainly developed along the layer discontinuities or along the fractures, especially if open. This determines the isolation of blocks with the consequent collapse of large portions of the cliff. The rate of retreat of the cliffs of Capo Caccia is estimated at an average of few centimetres per century (4-5 cm/century), even if the northernmost area close to Punta Cristallo (Figure 3) the rate can be considered triple.

**Figure 3**. The cliff of Punta Cristallo more than 300 m high

In different rock promontory almost exclusively inside the bay of Porto Conte a sea-level indicator, as a notch, has been found recurrently at some 3.8 m a.s.l. More precisely its altitude decreases from east (Punta Giglio) to west (Capo Caccia) across different rock promontories isolating little coves from an eustatic elevation of 5.5 to 3.45 m. According to several authors these differences is related to the accommodation by faults occurred along this continental margin (Antonioli et al., 2007).

Also in the western side of the promontory of Capo Caccia the +3,8 notch is preserved (Figure 4), but only inside the Neptune cave. Therefore, the preservation of such marker is due to the protection to the erosion as well as to the decreasing energy of waves inside the bay of Porto Conte. Such notch was formed during interglacial conditions, as witness the associated deposits, and is broadly comparable to the eustatic sea-level height reached during the substage 5e (Eutyrrhenian: 125 Ky b.p.) of the oxygen-isotope curve (Antonioli et al., 1998).

Close to the Grotta Verde this notch and the associated fringe of lithodomes was re-exhumed after the erosion of a landslide that covered it. According to the archaeological finds the age of the landslide is the Neolithic (Tanda, 1976). In fact, at the bottom of this cave, at present submerged by the sea, several human bones are found in some graves. This find, which look like a necropolis, permit to hypothesize that the coastline 7300 years ago was about 8.5 m below the sea level (Antonioli et al., 1998).

**Figure 4**. The Tyrrhenian notch "*survived*" in this protected stretches near Capo Caccia; a holocenic landslide buried and preserved this form subsequently re-exhumed by erosion of the foot of the landslide.

Along the cliff in study it is possible to follow continuously the present notch, even 1 m deep and 0,50 m high on average. This is likely due to the continuous action of the chemical dissolution of submarine springs (Cigna et al., 2003). Other palaeo-sea level marks can be seen only by divers' survey, as sea notches at the depth of 10 and 20 m. The submerged parts of the cliffs reveal widespread karst forms (Chessa et al., 1999; Orrù et al., 2005; Ginesu & Fasano, 2oo8), like the numerous underwater caves and conduits, partially altered by the marine current dynamics. The deepest forms are usually preserved worse.

## CLIFFS AS GEOMORPHOSITES

Among the different aspects of the coastal landscape, cliffs have always been a matter of interest and appeal, especially for the scenic component. However, in order to ensure their efficient protection you need to give them a scientific validation that is their consideration as geomorphosites. According to the original definition by Panizza (2001) a geomorphological landform (and process) that have acquired a scientific, cultural/historical, aesthetic and/or social/economic value is a geomorphosite. In order to this acquisition is therefore necessary to evaluate some parameters such as the knowledge of the site by experts, its representative in the area, its rarity in the considered geological asset, the degree of conservation, its exposure and ultimately its value added, i.e. its ability to have a further relevance to different aspects of the environment (ecological and/or naturalistic value, touristic and/or economic value, historical and or cultural value, protected area) (Coratza & Giusti, 2005). In the case of the cliffs of Capo Caccia and Punta Giglio each of these parameters is plentifully verified.

In particular, these cliffs are highly representative of the geomorphological evolution of the north-western coast of Sardinia. Such representativeness is confirmed by numerous research (see the reference list) also enlarged to the submerged part and to the caves. The modelling of the promontory of Capo Caccia occurred along NW-SE trending normal faults, which displace the carbonate sequence toward sea in the western side and toward mainland in eastern side.

The former side shows a plunging profile (Sunamura, 1992) with a face 300 m high that continues underwater down to depths of 50 m b.s.l., whereas the latter side is less steep and its sea-bottom does not reach great depths. Such eastern side, moreover, represent also the flank of a valley incised by a river in the maximum glacial time and then submerged by sea (Ginesu, 2004).

Punta Giglio represents the western flank of the valley, at present Porto Conte bay. The structural discontinuity, which affected the carbonate sequences, favoured an important karst system (Chessa et al., 1999; Cigna et al., 2003; Tuccimei et al., 2003; Ginesu & Fasano, 2008), better preserved in the side of bay than the western side. This fact put in evidence the retreat of the western cliff by waves and subaerial processes quicker than the cliffs inside the bay.

In this coastal environment there are also ecological aspects of primary importance both terrestrial and marine (Farris et al., 2007). In the first a large number of flower species endemic to Sardinia, attributed to a small areal extent or even that they have in the area of Capo Caccia-Punta Giglio the only world-wide distribution must be considered (Valsecchi, 1976). Within seconds the submarine biological community, quite heterogeneous, finds its maximum expression in the many ravines that are in the sea bottom and in the submerged part of the cliffs. Finally, as already mentioned, the peninsula of Capo Caccia preserves sites of archaeological interest. These sites from the early Neolithic may represent an added value to geomorphosite of Capo Caccia.

Such aspects, visible in a circumscribed territory, have become one of the major tourist attractions for the north-western Sardinia. Hence it could be considered an original offer for tourist in the sense of Pralong & Reynard (2005). This condition is evidenced by the 150,000 tourists who visit these places every year (Carboni et al., 2010). They exploit the easy accessibility to these cliffs (i.e. the Escala del Cabirol in Figure 5) and the opportunity to see the cliffs from different panoramic points, even from the boat; however in this case it has to sail at a safe distance.

**Figure 5**. Neptune Cave (photo on the right) accessible with the "*Escala del Cabirol*" (photo on the left), a straight ramp of about 660 steps "*carved*" on the ridge of the promontory

In reality the visit permit to see also the other environmental aspects, equally fascinating, as the caves, including that of Neptune, a true geological wonder (Figure 5), the sea-bottom so valuable for divers and the Mediterranean macchia with an impressive variety of plants to consider unique in the world. This multiplicity of issues has encouraged the establishment of the Marine Protected Area of Capo Caccia and Porto Conte, however being the coastal landscape affected by a series of morphogenetic processes that can make this vulnerable area and even put to risk the safety of visitors, it is necessary invest in interventions and protective measures.

## RISK ANALYSIS

In order to identify the risk areas of the studied coast, that also correspond to a Marine Protected Area and partially to a Regional Park, was made a map of geomorphological risk related to the instability of the cliff. This map at scale 1:25000 was carried out in a GIS environment. Its database was constructed in basis to the survey of the main fault lines, which are identified inland, and the detection of fractures recognized exclusively along the face of the cliff. This work has processed in various stages:

- Analysis of aerial photos;
- Image processing with AutoCad for the identification of homogeneous areas of cliff;
- Acquisition of raster data related to the different stretch of the cliff, and measurement of fractures;
- Implementation of the acquired data: number of fractures, type of fracture and relative measures and orientation;
- Calculation of the factor Danger Index by setting the function performed in a GIS environment.

Previously a geological survey integrated to the aerial photo analysis was executed in the coastal zone with aim to map the different lithology and the main tectonic lines, thus to make easy the distinction in homogeneous areas identified with AutoCad.

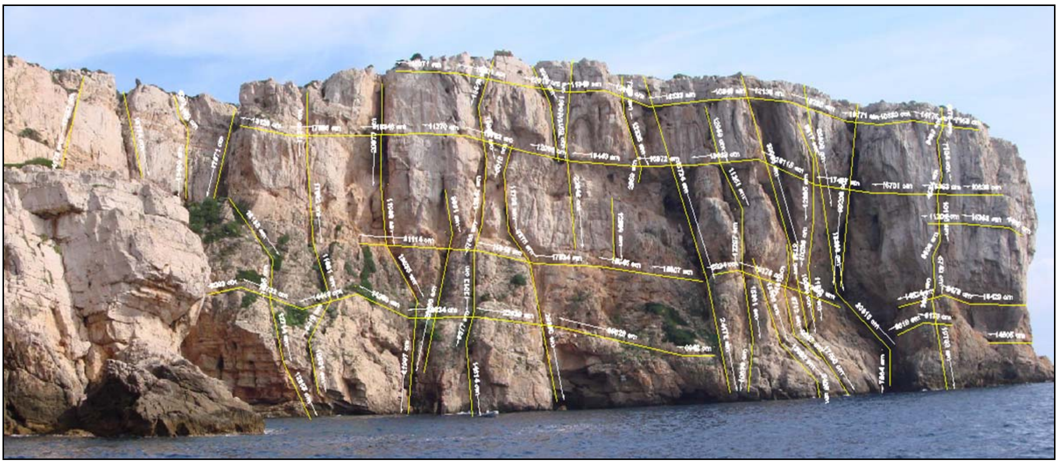

**Figure 6**. In the framework of the GIS, more than 3000 fracture orientation measurements were made on the cliffs of Capo Caccia and Punta Giglio (in the photo). Such measurements were made on the vertical cliff face through analysis photographs of the coastline, previously, along the wall, a graduate bar was placed that allowed in image processing to detect the length of the fractures

The method of investigation was carried out by acquiring photographic images of the cliff with an observer equipped with measurement bar (Figure 6). Subsequently the images were processed through a software that allowed the measurement of fractures as well as the height and the length of the cliffs. The fractures identified were classified into three types:

a. large cracks running through the entire cliff face;

b. fractures along layer stratification;

c. joints and minor fractures related to gravitational stress (Mortimore & Duperret, 2004).

Each area of the coast, identified in GIS, are linked to the available data (morphological parameters and type of fracture) measured in that area. The representation of the data in the layer RIL_FALESIA of the GIS system containing all the survey data indicated in three levels as "*Fractures*", "*Landslides*" and "*Elaborated Fractures*". The level "*Fractures*" contains the set of information obtained through the processing of data on the software "*Fotus*" by ACCA. Such software, moreover, allowed to obtain the data relating to the length of the fractures, after calibration and measurement on the ground. Each fracture was measured with an angle to the plane of the cliff and then with the program "*stereoNet*" has been made a "*Rose diagram*" to represent its orientation and direction. Such diagram was used to identify every fracture plane and compare it in terms of frequency over the entire area of competence.

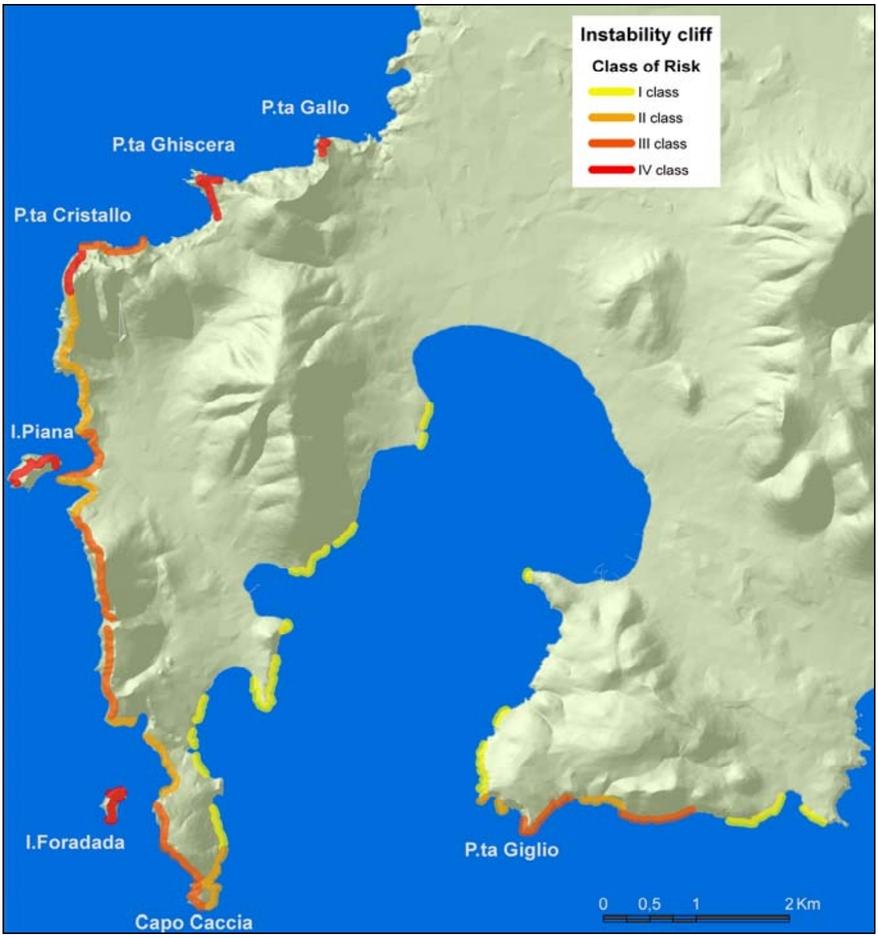


**Figure 7**. These 4 classes are mapped onto the coastline in a GIS format and the data related to the hazards is held in a GIS database developed by the authors and now held by the local authorities

In order to develop the formulas for assessing the risk (R) has assumed H as an index of the landslide hazard cliff highlighted on the cliff (H_I) and V as an index of environmental vulnerability of the coastal zone arranged by the use of the cliff. The former index was calculated by processing the data collected from the survey carried out along the cliffs. The intensity of H_I is mainly defined by the frequency of fractures measured in the surface unit on the cliff as well as by the number of landslides. Whereas the second index takes into account the position of fractures and landslides in basis to the function played in the Marine Reserve Area. Through the processing of data in a GIS environment we obtained indices that have allowed us to quantify the susceptibility to landslides and therefore the risk to lose this tourist resource in 4 classes (Figure 7).

Such classes has mapped, and that makes particularly perceptible the high risk present along the whole stretch of cliff on the northern coast of Alghero, where the cliffs show one of the higher coastal risk of Sardinia for the greater speed of retreat. This is evident by the lack of presence of notches and other paleo-sea level marks referable to the Tyrrhenian or previous stages. In addition, evidences of the erosive processes are evident by the numerous landslides that have been detected along the coast, both historical and recent. The sections with a higher instability, as it is noted from the map in Figure 7, are those exposed to the west (classes III and IV). These stretches are in fact subjected to the strong influence of the prevailing waves from the north-west. Moreover, in the northernmost stretch the risk are emphasized because of outcrops of gypsum and clays, Triassic in age. Much lower instability, which also corresponds to a lower risk, is attributed to the cliffs inside the bay of Porto Conte.

## CONCLUSION

The text and photos relative to the geomorphosite of Capo Caccia, presented in this paper, can only minimally to highlight the geological, cultural and economic heritage (Reynard et al., 2009) preserved in this place for its many visitors. Not only the cliffs, but also the bay which lies between them, beautifully represent the geological history of north - western Sardinia and testify with its emerged and submerged landforms the dynamic interaction over time between the sea and the island. In this dynamic is well integrated a remarkably diverse plant and animal population in both emerged and underwater habitat.

This has encouraged the establishment of a Marine Protected Area, and also the promotion of a series of measures to safeguard the entire coast. Such measures are necessary for the great number of visitors, coming in this site every year, attracted by the suggestive landscape, but also by the opportunity to dive in fascinating submerged areas, to bathe inside a spectacular bay, to enter into wonderful caves. However they can determine directly and indirectly with the activities they induce significant impacts (Agardy, 1993).

Therefore, public and private institutions have developed an integrated system capable of offering tourists goods and services of high quality, and avoid compromising the environment as a whole. However, they cannot overlook a fundamental natural look: the high and rocky coasts are inevitably subject to erosion, whose phenomena can cause a risk to those who use the site (Coratza & De Waele, 2012). To this end it is necessary to assess the level of risk to which they may be subject to the tourists, so as to help the institutions to intervene mitigating it with specific and appropriate interventions (Coratza et al., 2008; Poch and Llordes, 2011). The approach presented in this paper is in this direction and can be applied in other coastal areas where you want to ensure a sustainable and responsible tourism in areas with natural resources of great value.

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# GEODIVERSITY: A NEW QUANTITATIVE INDEX FOR NATURAL PROTECTED AREAS ENHANCEMENT

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**Abstract:** In spite of the excellent results achieved by international scientific community, the topic of quantitative evaluation of geodiversity is still an open issue. The estimating models including the assessment of abiotic characteristics need to be improved by means of quantitative analysis of geological and geomorphological components. In this work an evaluation based on an Index of Geodiversity (Geodiversity Index, GI), easily inferable by GIS analysis, is proposed. The test area corresponds to the Subasio Mountain Regional Park (Umbria – central Italy), an excellent site for the abiotic components evaluation.

**Key words:** geodiversity, geomorphic analysis, GIS, Umbria, central Italy.

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## INTRODUCTION

Natural heritage is the main renewable resource of Italy, due to the wide diversity characterising its physical landscapes. The complex geological and geomorphological setting, coupled with the variability of topographic and climatic features, trigger a dynamic evolution of natural systems. They are at the basis of the ecosystems survival, contributing to the uniqueness of the Italian territory.

The diversity of a natural ecosystem depends on biotic and abiotic components. Usually, the natural variability is identified with the biotic diversity, or biodiversity, whose short time development and evolution highlights the fragility of this component. Therefore, the scientific community, especially after the United Nations Conference on Environment and Development (UNCED), also known as „*the Rio Summit of 1992*", has devoted a great deal of attention to biodiversity enhancement and protection (Pimm et al., 1995; Myers et al., 2000; Petterson et al., 2013).

Although several scientists, mainly from northern Europe (Scotland, Germany, Switzerland), have focused on some geological rarity since the end of the 19th Century, only from a few decades geologists and geomorphologists have introduced the concept of geodiversity in the study of natural heritage. The close relationship between the abiotic and the biotic components has been investigated, including also the human presence and the related cultural heritage. Then, geodiversity was defined as „*... the link between people, landscape and culture, the variety of geological environments, components,*

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*phenomena and processes that constitute them showing in a variety of rock types, minerals, fossils, and soils that provide the frame of life on Earth*" (Stanley, 2002). Over the years, geodiversity was defined as "*the natural range (diversity) of geological (rocks, minerals, fossils), geomorphological (landforms, physical processes) and soil features*" (Gray, 2004). Later, also topographic and hydrographic elements were introduced in this definition (Serrano & Ruiz-Flaño, 2007a, b; Gray, 2008).

The values of geodiversity were separated into four groups (Gray, 2004). The first was referred as to the intrinsic value or "*the ethical belief that some things (in this case geodiversity) are of values simply for what they are rather than what they can be used for by humans (utilitarian value)*" (Gray, 2004).

The second was the cultural and aesthetic value assigned by a community for which a particular site plays an important role in terms of cultural and historical heritage; the third was the economic aspect, as the geodiversity can be an economic resource, sometimes of prime importance for the areas in which it is recognized. The last one was the scientific and educational value: the importance of geodiversity as a topic of scientific research, teaching and dissemination.

Other authors (Panizza & Piacente, 2008) defined the geodiversity value as:

1. intrinsic, according to the geological complexity of the study area;
2. extrinsic, in relation to geological differences when compared to other areas;
3. simple, covering the whole range or the diversity of geological objects in an area without value attribution;
4. complex, referred to specific geological systems with an high diversity.

Hence, it is clear the geodiversity is the essential starting point to guarantee not only the biodiversity, but also the entire natural diversity of physical landscape.

Several authors highlighted that this aspect has always played a secondary role, both in scientific fields and in administrative decisions and legislation on environmental protection (Milton, 2002). This is even less understandable when we consider that areas with an high value of geodiversity are at risk, too often underestimated (Lazzari et al., 2006; Kiernan, 2010). Human pressure, accelerated erosion, indiscriminate exploitation of natural resources are the main causes for hazard increasing.

Recently, several studies (Fronzek et al., 2006; Prosser et al., 2010) have shown a real risk related to the geodiversity losing. This is particularly evident in areas where global climate change modifies temperature and rainfall values trend, increasing the effectiveness of morphogenetic processes. For this reason, the only realistic possibility to preserve the geological heritage is to sensitize and influence the political actions. So, after the art. 2 of the Convention on the Protection of World Cultural and Natural Heritage (UNESCO) signed in Paris in 1972, the international scientific community started to identify areas with high value of geodiversity, basing on the definition and identification of „*geosites*" or any place, area or territory representing a rarity of geological and geomorphological events with a consequent interest for conservation. In Italy, this has resulted mainly in the identification of geosites, geological routes and geoparks foundation (Poli, 1999; Carton et al., 2005; Gregori & Melelli, 2005; Gregori et al., 2005; Reynard & Panizza, 2005; Reynard & Coratza, 2007).

Nowadays, the geodiversity definition, evaluation and recognition represent some of the most important targets for Earth Sciences. However, despite the excellent results achieved by scientific national and international research, the quantitative assessment of this parameter is still an open field.

To this aim, some quantitative models have been proposed (at medium and small scale) although the number of scientific works on the subject is still low (Ibáñez et al., 2005, Serrano & Ruiz-Flaño, 2007a, b; Jačková & Romportl, 2008; Benito-Calvo et al., 2009; Hjort & Luoto, 2010). It is to note that most of these works are far to propose a unique method that can be consistently used for a territory holding so many different characteristics like Italy (Massoli-Novelli & Petitta, 2001; Panizza, 2009; Giardino et al., 2012).

The idea that we put forward here is to develop a quantitative formulation which is able to define the components related to terrain data from a geometric-morphometric point of view rather than a semantic one (Pike, 1995; Goudie, 2004; Taramelli & Melelli, 2009 a, b). To this aim, the Geographic Information Systems (GIS) appear the most straightforward analytical tools that can take into account quantitatively the spatial relationships between study objects to define numerical indices (Melelli & Floris, 2010).

With this paper we aim at contributing to produce a spatial analysis tools that might become an incentive for the scientific, cultural and economic development for the identified areas.

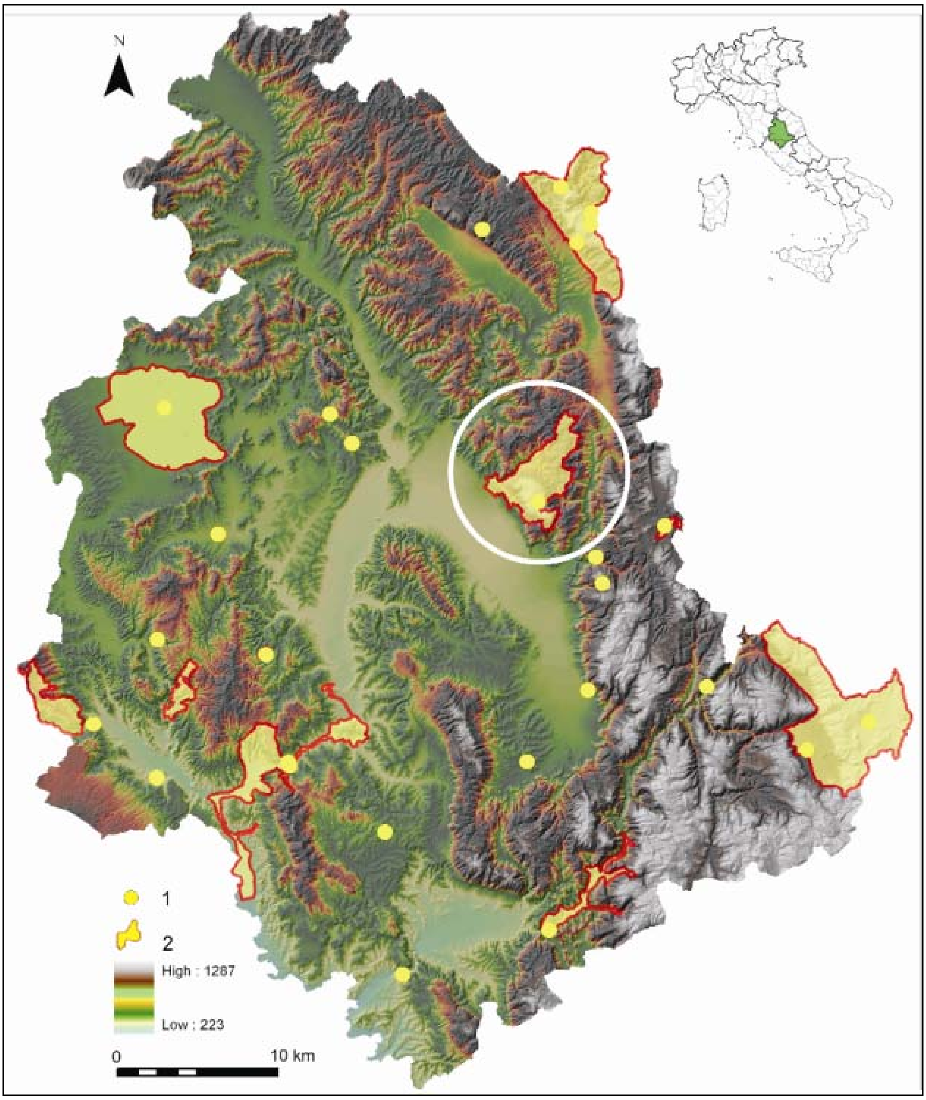


**Figure 1**. Location map of the Umbria Region (central Italy). The white circle marks the Subasio Mt. Regional Park. (1) Geosites, (2) Regional Parks

## THE TEST AREA: SUBASIO REGIONAL PARK (CENTRAL ITALY)

Subasio Mountain regional Park is located in Umbria (central Italy), a region with a well known natural heritage, where twenty-seven geosites are already individuated and studied. This region also hosts seven regional and one national natural park (Figure 1).

The Subasio Mt. Park covers a surface area of 7.200 hectares and is delimited southward by the homonymous mountain (1.290m a.s.l.). To the west the boundary follows the Tescio River, bordering gentle slopes where terrigenous formations crop out. The litotypes of this area can be clustered into three main complexes; several different types of overlying Holocene deposits (alluvium, colluvium, debris and landslide bodies) are also widespread (Figure 2, Melelli et al., 2012).

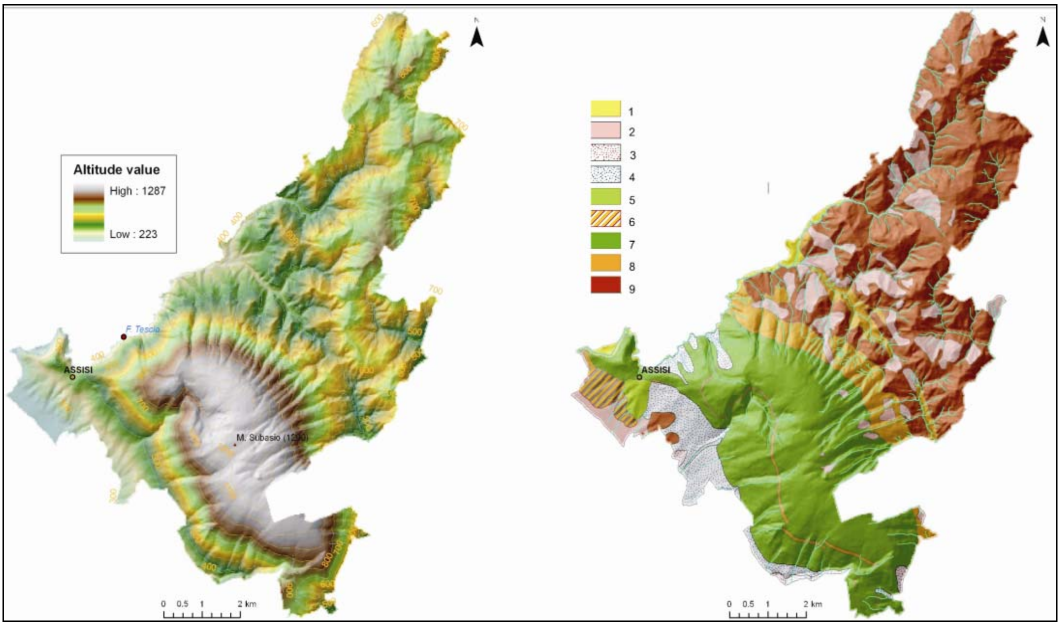


**Figure 2**. Left: DEM of Subasio Mountain Regional Park (altitude values in meters a.s.l.) Right: geological map: (1) Alluvial deposits, (2) Colluvial deposits; (3) Debris deposits (active); (4) Debris deposits (ancient); (5) Fluvial Lacustrine complex; (6) Travertine; (7) Calcareous complex; (8) Terrigenous complex with prevalent clay; (9) Terrigenous complex with prevalent sandstone

The calcareous Complex (upper Trias – Oligocene) crops out in the southern sector, on slopes of the rounded antiformal ridge of Subasio Mount. The terrigenous complex (Miocene) is divided in two parts, depending on the clay percentage, and covers the leftover of the study area. The surface deposits (Pliocene – Holocene) have different genesis, fluvial-lacustrine the most ancient, debris, colluvial and alluvial the recent ones. Despite the test area is quite limited in its extension, a great variety of lithotypes crop out, involving a very diversified morphological arrangement. The highest altitude and amplitude of relief values are on the calcareous complex, whereas the terrigenous formations show gentle slopes, occasionally cut by deep and narrow valleys.

From a geomorphological point of view (Figure 3), karst landforms occur on the top of Subasio Mt., with large dolines locally named "*mortari*". The leftover of the antiformal ridge is characterized by structural and fluvial landforms. The main part of the park area is characterized by an active morphogenesis with fluvial features, both erosional and depositional, due to the high erodibility of the terrigenous formations. There are also a significative number of mass movements along the Subasio Mt. slopes.

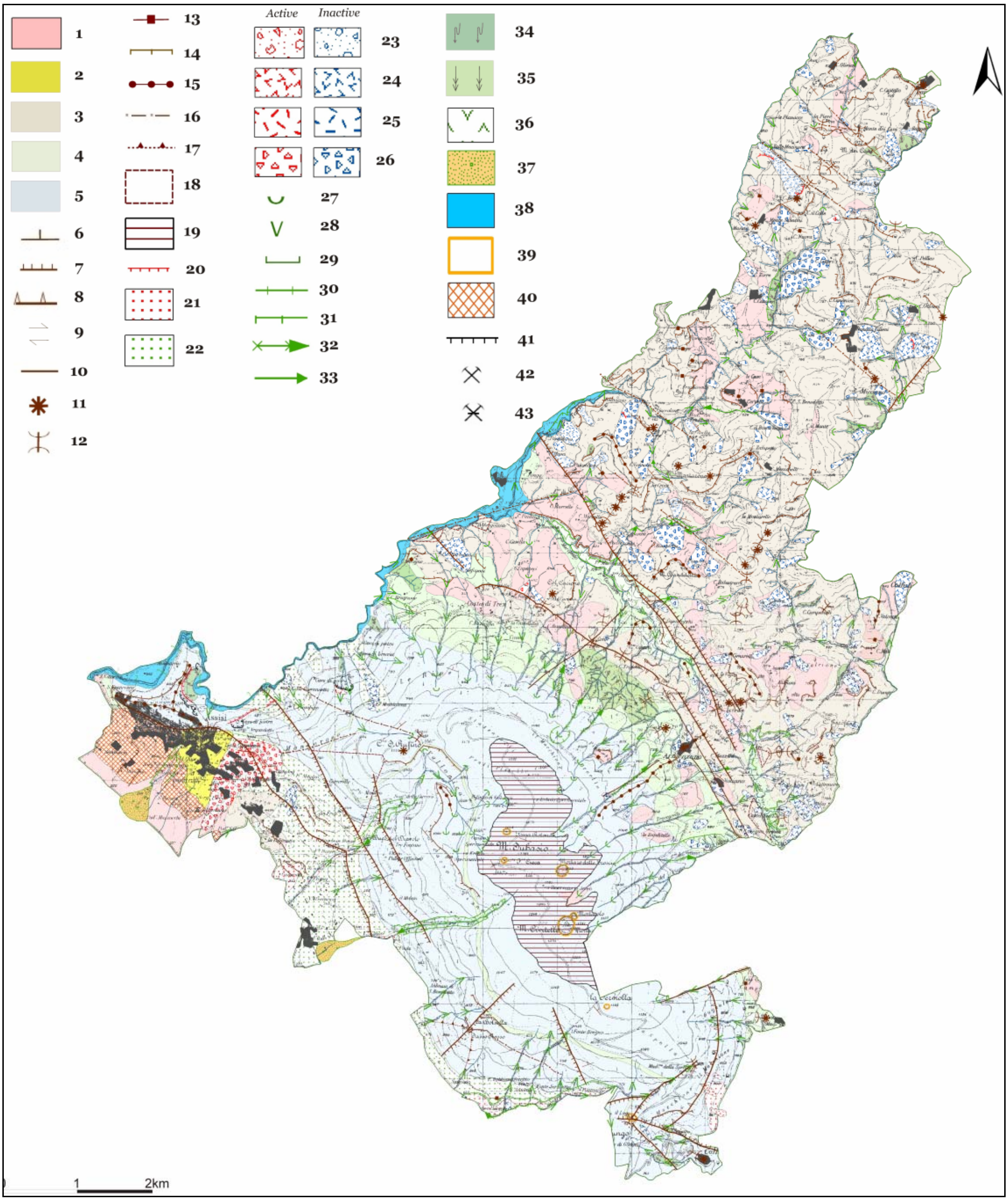


**Figure 3**. Geomorphological map of Subasio Mountain Regional Park (Melelli et al., 2012)
1) Colluvial deposits, 2) Fluvial lacustrine deposits, 3) Terrigenous complex (sandstone > clay), 4) Terrigenous complex (sandstone < clay), 5) Calcareous complex, 6) Dip direction, 7) Normal fault, 8) Inverse fault, 9) Transcurrent fault, 10) Fault, 11) Peak, 12) Saddle, 13) Break slope, 14) Escarpment, 15) Ridge, 16) Lineation, 17) Flatiron, 18) Triangular facet, 19) Structural surface, 20) Gravitational escarpment, 21) Debris (actual), 22) Debris (recent), 23) Flow, 24) Slide, 25) Fall, 26) Complex, 27) U shaped valley, 28) V shaped valley, 29) Flat bottom valley, 30) Gorge, 31) Fluvial escarpment, 32) Gully erosion, 33) Elbow, 34) Sheet erosion, 35) Gully erosion, 36) Badland, 37) Alluvial fan, 38) Alluvial deposits, 39) Dolina, 40) Travertine, 41) Anthropic escarpment, 42) Quarry (active), 43) Quarry (inactive)

Due to the variety of lithotypes, covering deposits and geomorphological processes, the study area represents an excellent natural laboratory to test the geodiversity influence on the landscape aspect and evolution. Moreover, the Subasio Mt. Park is characterized by high cultural and architectural values, such as the town of Assisi, with the marvelous basilica declared as a UNESCO world heritage site and numerous historical and religious sites, assuring to this area a steady flow of tourists and pilgrims from all over the world.

## GEODIVERSITY INDEX (GI) EVALUATION

The spatial analysis in GIS makes use of numerical methods that compare spatial data in vector format (geometric elements that shape the geographic reality in points, polylines or polygons) and grid (raster, in a matrix format with resolution equal to the side of the cell, associating a spatial attribute to each cell).

The formula for Geodiversity Index (or GI) evaluation, as amended by Serrano & Ruiz-Flaño (2007a; b) is the following [1]:

$$GI = \frac{\left[\left(\sum_{i=1}^{n} V_i\right) + \left(\sum_{i=1}^{n} G_{mi}\right)\right]\left(\frac{S_a}{P_a}\right)}{\ln S_a} \quad [1]$$

Where:

$V_i$ (Variability function) is each abiotic factor contributing to the geodiversity definition with intrinsic characteristics of spatial continuity (i.e. lithotypes, land use classes);

$G_{mi}$ (Geomorphology factor) is each abiotic factor contributing to the geodiversity definition with intrinsic characteristics of spatial discontinuity (geomorphological features, landforms);

$S_a$ (Surface area) is a raster in which the cell values reflect the true topographic surface area within that cell;

$P_a$ (Planimetric area) is the square of the resolution of the Digital Elevation Model (DEM) representing the topographic surface.

The data used to calculate $V_i$ in [1] include: geological data in vector format deriving from the map of geological complexes (Figure 2) and land use in vector format from the Corine Land Cover project (scale 1:100.000; EEA, 2007). Each theme is converted into a grid where the variability of the data is calculated in a moving window (a circle of radius equal to 75m), using neighborhood analysis and a focal statistics function. The statistical calculation of the values contained within the moving window, repeated for each cell, is shown as output in the central cell of the window, then the grid is reclassified in three classes with an increasing degree of variability (Figure 4). This type of analysis is possible according to the spatial continuity of the data (there are no areas with -no data- in a geological map or in a land cover one).

The second term ($G_{mi}$) is the sum of abiotic factors (with no spatial continuity in the mapping process). The geomorphological data can be represented in some vector layers, corresponding to the different landform units, and then converted in a grid format. The conversion creates layers without continuity, being several -no data- values between the landforms. Furthermore, two or more geomorphological processes can be present in the same spatial location (cell). As an example, on the top of the Subasio Mt., some macro-dolines are superimposed on a structural surface. Due to the different and very complex representation of this kind of data, a different spatial analysis is used. All the landforms belonging to one morphogenetic process are merged. Then, all the layers corresponding to geomorphological processes acting in the study area are summed by local functions "*plus*" and then the output layer is reclassified (Figure 5).

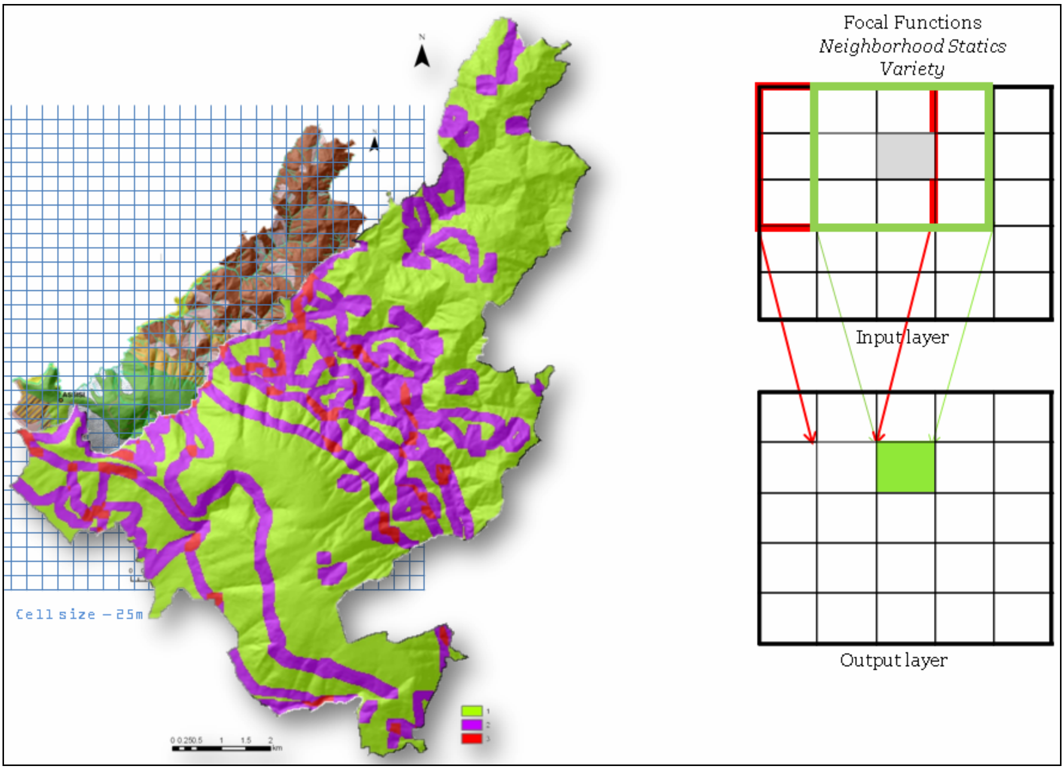


**Figure 4.** The neighborhood function "*variety*" determines the number of unique values (or variety) for each cell location on an input raster within a specified neighborhood and sends it to the corresponding cell location on the output raster

The highest values of $G_{mi}$ correspond to the areas where multiple and simultaneous morphogenetic processes occur.

The remaining parameters, expressed by Sa (surface area) and Pa (planimetric area) enhance the role of topographic factor in the geodiversity estimation and are directly calculated from a Digital Elevation Model (DEM). Irregular topographic surface, with high values of terrain roughness (a term used to describe how "*irregular*" an area is) identifies zones where depressions and ridges are alternated in a short distance, that may be due to causes related to a more complex geological structure, and/or to different type and effectiveness of geomorphological processes. Summarising: the higher the roughness, the more is the erosion intensity and, therefore, the higher the density of landforms.

The roughness is derived from a DEM with a 25x25m cell size, according to the same spatial resolution of the other grid data. The topographic indexes (Sa, Pa) are computed using the „*Surface Area and Ratio*" tool for ArcGIS (Jenness, 2004). In detail, Sa is a raster in which the cell values reflect the real topographic surface area within that cell, directly proportional to terrain irregularity and therefore higher in mountainous areas and lower in flat ones. Pa corresponds to the square of the resolution of the elevation model. The ratio between Sa and Pa is taken as a measure of topographical irregularity or roughness (Jenness, 2004).

The final step is to apply the formula in a procedure of spatial analysis, overlaying the datasets of variability; each data must be classified in three classes, to assure the same weight to each layer (Figure 6).

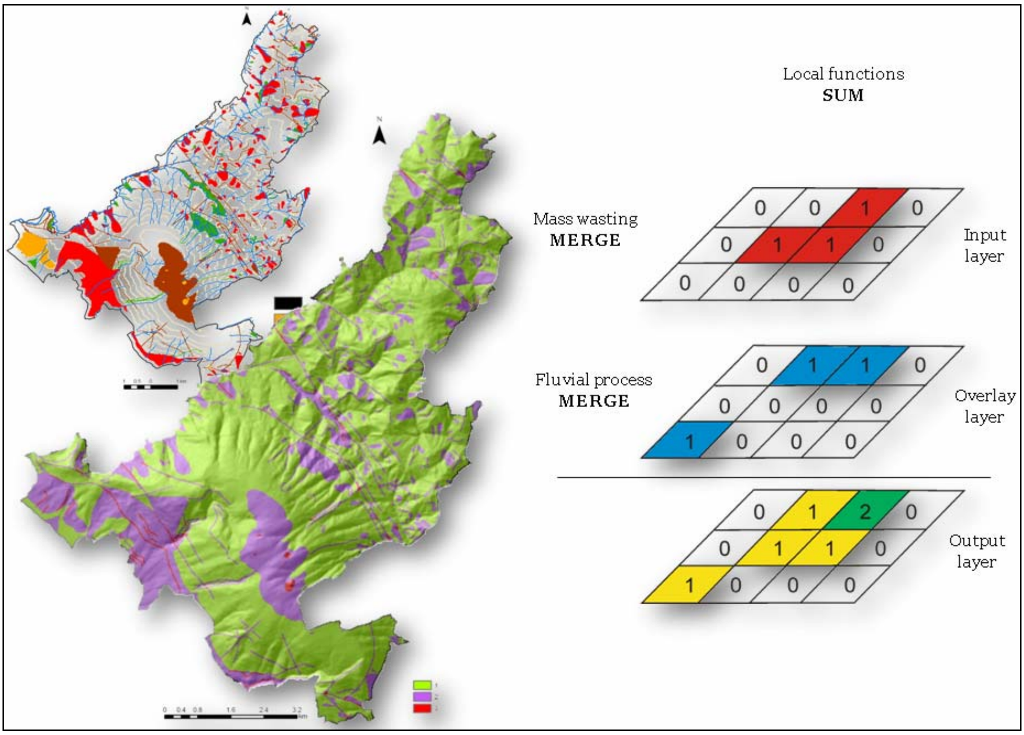


**Figure 5.** $G_{mi}$ as the sum of geomorphological data. All the layers corresponding to geomorphological processes acting in the study area are summed by local functions "*plus*" and then the output layer is reclassified in three classes with a decreasing degree of variability.

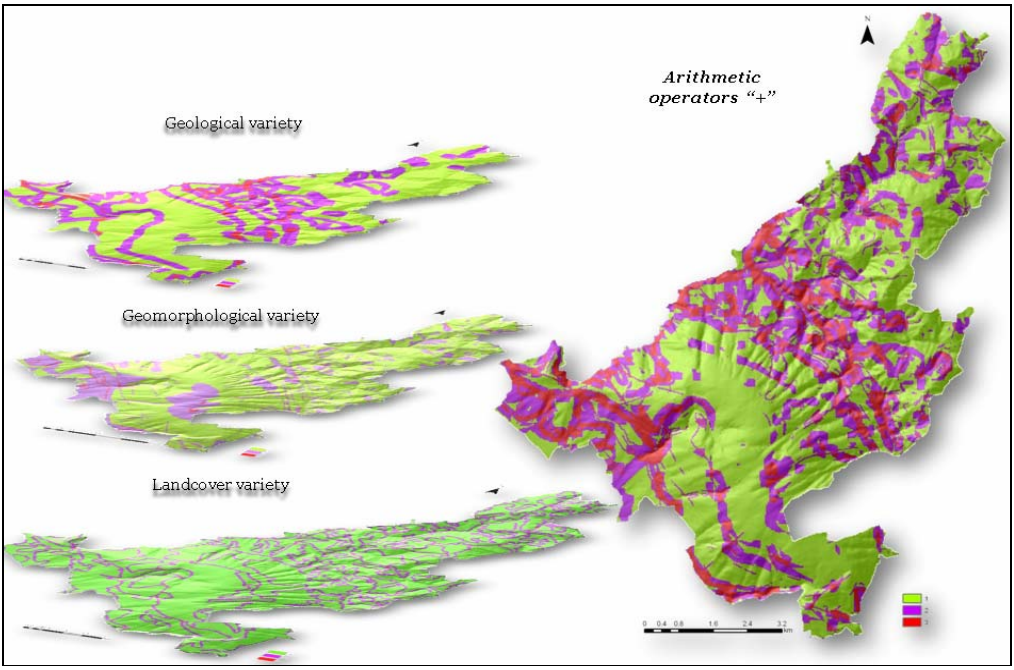


**Figure 6**. Overlapping input themes. On the right, the resulting grid of geodiversity index

The resulting Geodiversity Index map of regional park of Subasio Mountain is classified in three classes with null or low, medium and high geodiversity value as shown in Figure 7.

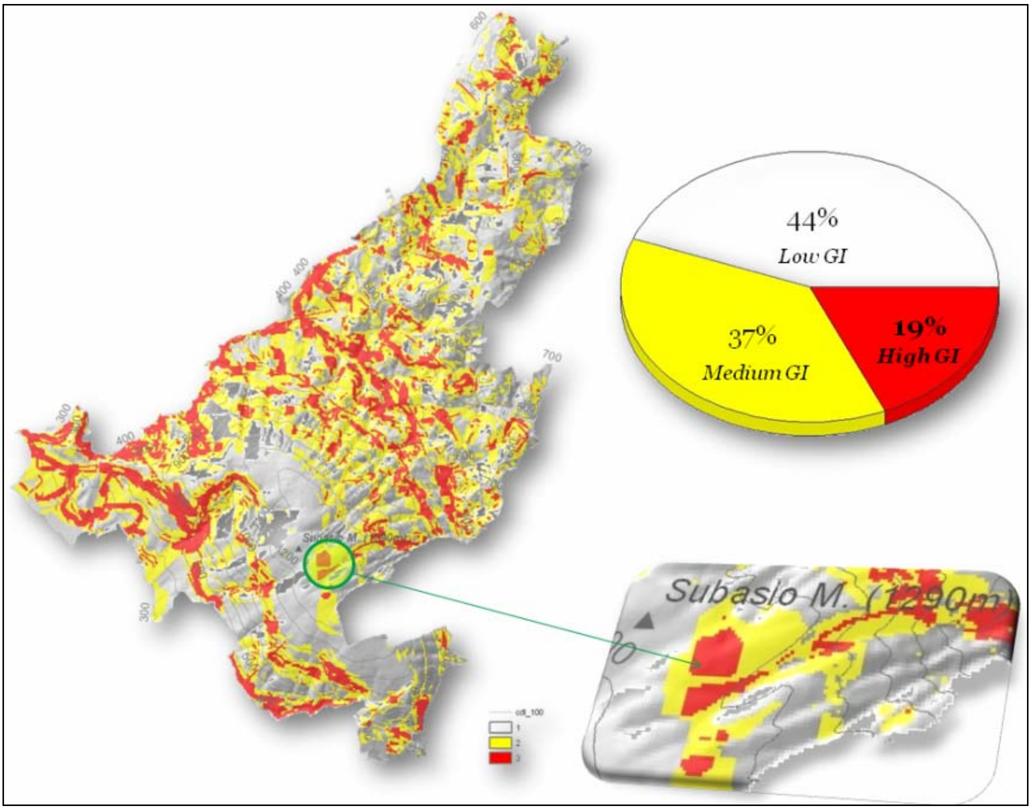


**Figure 7**. The Geodiversity Index map for the Subasio Mt. Regional Park
1) Null or low value, 2) Medium value, 3) High value. The lower right enlargment
shows high GI values corresponding to macro-doline (geosites).

The reclassification assigns the break values according to natural groupings inherent in the data. Class breaks are identified where similar values are best grouped and where the breaks maximize the differences between classes, as a result the boundaries classes are set where the highest differences in the data values are present (De Smith et al., 2006/9). Nineteen percent of the territory is characterized by a high value of geodiversity and the thirty-seven percent with a medium value. The maximum Geodiversity Index value is confined in particular topographic and geomorphological assessments. High value of geodiversity matches the geosites like the macro-doline on the top of the Subasio Mountain or where two or more geomorphological processes are acting. Moreover, the same classes correspond to high values of topographic index where the morphogenesis is faster. In addition, these areas correspond also to zones where an intense fluvial deepening is carving several gorges in the terrigenous complex.

**FINAL REMARKS**

The management of natural parks and protected areas can find in the improvement of the abiotic component a new impulse for environmental enhancement. Geodiversity is the starting point that can guarantee the variability of an ecosystem and the survival of unique landscapes and, above all, of different forms of plant and animal life (biodiversity). Geodiversity is strictly linked to the presence of geosites and, in the natural parks, it is a necessary condition to promote the protected areas. Indeed, according to geoparks definition, a geopark is a territory which includes a meaningful geological heritage and a sustainable territorial development strategy. To this aim, an unbiased evaluation of the geodiversity is an essential tool to assess the effective presence/absence of abiotic heritage.

In order to evaluate the geodiversity, qualitative remarks are well defined and widely available in scientific literature; however, a quantitative method is advisable. This approach assures the advancement of knowledge on the identification of geodiversity for the development of the natural heritage.

It is also an additional method which can be in principle used in different areas, a final upgradable digital database, a tool to identify areas with potential value of the abiotic component, and an instrument for economic development and conservation management. The aim is to predict potential evolution and transformations of land uses and planning the proper management of natural heritage.

Concluding, in this paper a GIS analysis method is described, where different spatial analysis tools are used, in order to obtain a digital dataset that parceled the test area in three classes of geodiversity (null or low, medium and high).

This approach might aid in achieving important objectives, such as the implementation of a computational model for geodiversity at different scales, a better definition of the parameters defining geodiversity, and an unbiased procedure to build a model of spatial analysis in the GIS environment, suitable for an automatic determination of the Geodiversity Index.

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# GEOTOURISM IN THE ABRUZZO, LAZIO AND MOLISE NATIONAL PARK (CENTRAL ITALY): THE EXAMPLE OF MOUNT GRECO AND CHIARANO VALLEY

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**Abstract:** The geomorphological landscape of the Abruzzo region is a great example of a variety and complexity of processes and morphogenetic events as well as all the Italian territory. Here, complex Mesozoic-Cenozoic palaeogeographies are still reflected by the main mountain chains of Abruzzo and offer scientists and tourists imaginary journeys through ancient, now vanished, coral atolls and blue deep seas. Valleys of glacial or fluvial origin, alluvial fans, present and paleolandslides still preserve the memory of these ancient landscapes. In Abruzzo, Lazio and Molise National Park, where all of these landscapes are incorporated, the educational enhancement of geological and geomorphological themes has been pursued, with the creation and installation of information panels, theme trails and geotourist maps. In this framework, this paper illustrates methods, initiatives and activities for the enhancement of geological landscape and geomorphosites, and particularly the Geotourist map of Mount Greco e Chiarano Valley. This map allows for the presentation of rocks and landforms of an awesome landscapes within the park in an easy-to-understand way, by means of different types of tools such as: 3D reconstructions, aimed to provide a three-dimensional perception of geologic processes and elements; landforms highlights, aimed at increasing the perception and identification of landforms and processes, as well as their impact on the landscape; palaeo-geographic reconstructions and cartoons, aimed at showing the evidence of landscape evolution. Main objective of the map is to enhance the geological heritage of a

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peculiar landscape in the Park and to make people aware that the present day landscape (i.e., a valley, a ridge, a landslide, but also a rock, a fracture) is the result of a millions to hundreds of millions of years of a dynamic evolution ongoing until now and the future. Through the comprehension of the present landscape it is possible to explain to the public (from very young to aged) the geological history written in rocks and landforms and to make people aware of the very high dynamics of the landscape, which provides outstanding landscapes but also natural hazards and risks.

**Key words:** geomorphology, geotourism, Abruzzo, Lazio and Molise National Park, Mount Greco – Chiarano Valley.

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## INTRODUCTION

The geologic and geomorphologic landscape of the Abruzzo region is a good example of the variety and complexity of processes and morphogenetic events in Italy. Due to the spatial coexistence of many well-preserved elements of both a complex structural evolution and landform development, the Abruzzo region has become a geological and geomorphological platform that is famous worldwide (D'Alessandro et al. 2003; Patacca & Scandone 2007; Cosentino et al. 2010; and references therein). Since the late 19th century, geologists, petrologists, palaeontologists and geomorphologists have extensively explored the Central Apennines and, in particular, the territory of Abruzzo—a rough, inaccessible landscape, almost impassable in ancient times—trying to decipher and reorganise the fabric of its geological history (among others, Cassetti 1900, 1904, 1909; Sacco 1907, 1928; Oddone 1915; Beneo 1938, 1940; Almagià 1910, 1919; Sestini 1933).

Since the beginning of the 20th century, a specific protection policy for the safeguarding of this landscape has been in place, first and foremost through the creation of the National Park of Abruzzo, followed by a gradual expansion of the policy through the establishment of a system of national and regional parks. This park system now includes the National Park of Abruzzo, Lazio and Molise, the National Park of Maiella, the Gran Sasso and Laga Mountains National Park and the Regional Natural Park of Sirente–Velino. In total, the area covered by these parks represents about one third of the surface area of Abruzzo (Figure 1).

Parks and reserves safeguard rock exposures, ecosystems, landscapes, species and botanical associations, habitats and staging points for fauna, which are all typical of the regional territories. Recently, however, they have also started playing an active role in scientific research, in environmental education, in the conservation and maintenance of the local ecological balance, in the recovery and enhancement of the historical and geological heritage, and in the promotion of environmental values, with a strong focus on tourism activities. Finally, the establishment of a system of parks in the Abruzzo region is the most effective way to protect geomorphosites and geosites within a specific legal framework. Over the last few decades, geosites and geomorphosites have been subject of research, primarily through assessment, enhancement, inventories and protection approaches.

Inside the park areas the enhancement process mainly consists, so far, in the creation of geological on site information panels – currently being set up in the National Park of Abruzzo, Lazio and Molise (Miccadei et al., 2011) – of geological and geomorphological itineraries – as those proposed in the Gran Sasso and Laga Mountains National Park – and of the geotourist maps (Piacentini et al., 2011). Several geological and geomorphological field trips have been carried out in the Abruzzo region and particularly in the National Park of Abruzzo, Lazio and Molise, all for to contribute to the development of geotourism. The primary goals of the itineraries, information panels, geotourist maps, and field trips are to highlight the geological and, in particular, geomorphological features of the landscape, and to outline relations between the identified landforms and related processes and tourist–recreational activities. This is focused on both increase the knowledge and awareness of the general public and assess accessibility features and intrinsic geological and geomorphological risks (Piacentini et al., 2011).

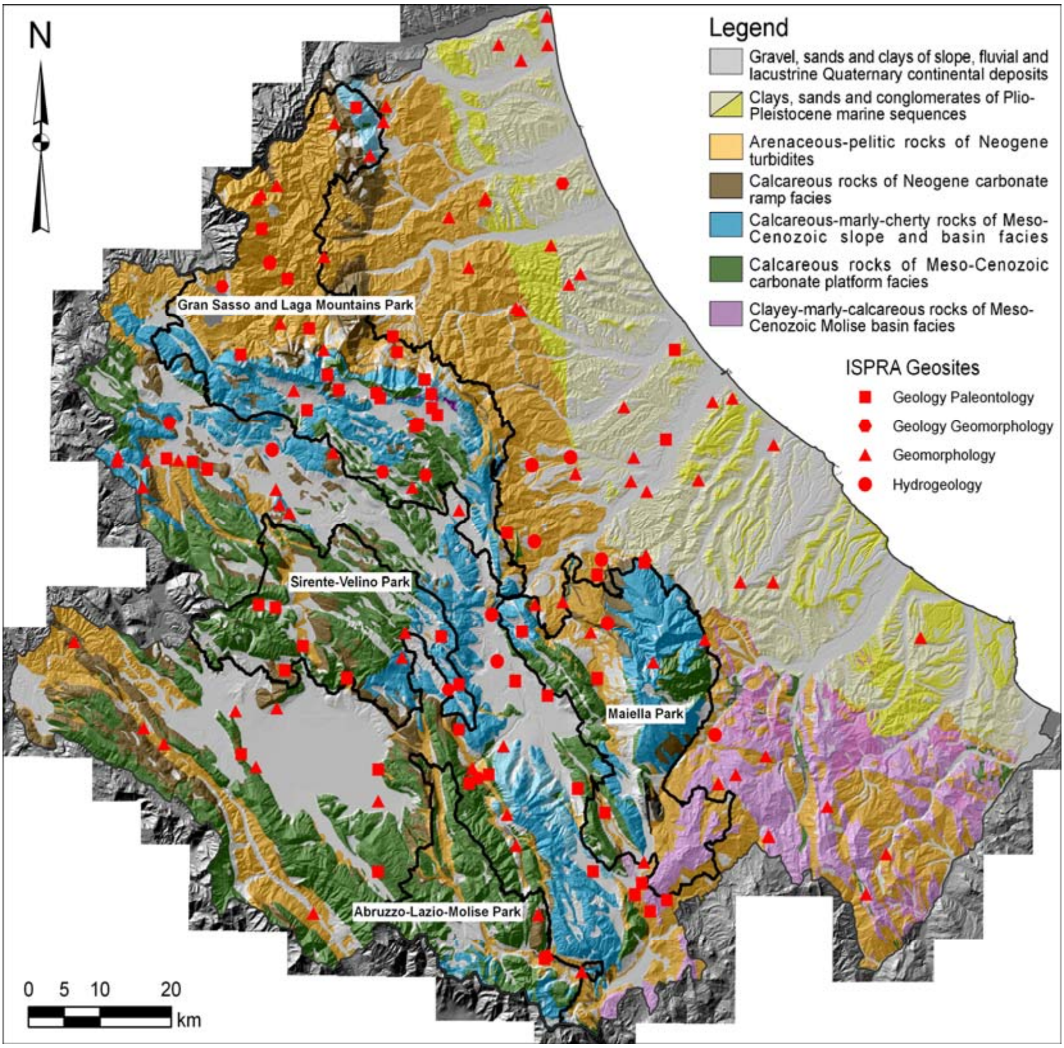


**Figure 1**. Geological setting of the Abruzzo Region and geosites from the ISPRA database (ISPRA, 2011); Black lines indicate the location of Abruzzo's national and regional parks (DEM provided by the Cartographic office of Regione Abruzzo) (Source: Miccadei et al., 2011)

The activities carried on and ongoing in the Abruzzo area include experiences at regional and institutional level, as well as at university level, in same cases in collaboration with upper school institutions. They also include activities developed specifically for tourism at local and regional scale or private initiatives, within the

Park areas or within the Italian Association for Geology and Tourism. This contributes to a wide interregional tourism network integrating initiatives targeted at various potential users and connecting universities, local and regional institutions, Parks and local reserves, schools, private initiatives etc., and can lead to reach the goal in term of educational dissemination of geological and geomorphological themes, awareness of the complex meaning of the landscape (Piacentini et al., 2011).

In this framework, this paper illustrates methods, initiatives and activities for the enhancement of geological and geomorphological landscape in the Park of Abruzzo, Lazio and Molise, and particularly the Geotourist map of Mount Greco and Chiarano Valley. Geographically, this area is adjacent to the Park and is one of the most beautiful in the Peligna region, just to the east of the Marsica area (Figure 2).

The geotourist map emphasizes the relationship between geology s.l. and landscape, showing how different structural factors and geomorphic processes can produce different features and behaviour of landscape and territory. More in general, this paper presents methods and tools for the promotion of geotourism in the Abruzzo Parks.


**Figure 2**. Geographical setting of the Abruzzo, Lazio and Molise National Park,
Red line indicate the Mount Greco – Chiarano Valley area

## THE STUDY AREA

The regional morphostructural setting of Abruzzo is defined by three main morphostructural domains: the Apennine Chain, Piedmont and Coastal Plain. The system of national and regional parks includes mostly the chain area, characterised by a highly unique rough landscape and wild nature. Here, Mesozoic-Cenozoic palaeogeographies are still reflected by the main mountains ridges of Abruzzo and offer scientists and tourists imaginary journeys through ancient, now vanished, coral atolls and blue deep seas. Valleys of glacial or fluvial origin, alluvial fans, present and paleolandslides still preserve the memory of these ancient landscapes (Figure 1).

The topographic relief of the Apennine Chain is made up of carbonate ridges (NW–SE, NNW–SSE, N–S) separated by parallel valleys carved in terrigenous foredeep deposits or filled up with continental ones and by wide intermontane basins partially filled with continental deposits. To the east, the relief abruptly slopes down into the hilly landscape that is carved by cataclinal valleys (SW–NE) in a gently NE-dipping homocline of clay, sand and conglomerate deposits. Along the valleys and close to the coast, alluvial plains join a narrow Coastal Plain (D'Alessandro et al., 2003; Miccadei et al., 2004).

Orographically, the Park area is characterized by a relief arranged as a series of ridges NW-SE and NS oriented, with elevations ranging between 1800 m and >2200 m a.s.l., separated by deep fluvial valleys and hanging glacial valleys; plains can only be found in the eastern area (Castel di Sangro; Capelli et al., 1997). The ridges are frequently interrupted by secondary valleys, both parallel and transverse to the main valleys. In detail, the Mt. Greco – Chiarano ridge is characterized by peaks elevation between 2000 m a.s.l. and 2300 m a.s.l. (Serra Sparvera 1998 m a.s.l.; Serra le Gravare, 2143 m a.s.l.; Serra Rocca Chiarano, 2262 m a.s.l.; Mt. Greco, 2285 m a.s.l.).


**Figure 3**. Pantaniello Lake (1818 m a.s.l.)

The ridge is deeply incised by valleys of the main rivers (Sangro River, Profluo Creek and Tasso Creek) and their tributaries. The hydrography is characterized by a well-developed drainage network; the pattern is predominantly angular type with two preferential directions, NNW-SSE and NE-SW respectively; along some main valleys, the pattern becomes trellis-type, related to the steep calcareous slope and locally to clayey-sandstones spots in the lower part of the valleys.

One of the most beautiful tourist destinations in this area is Pantaniello Lake (1818 m a.s.l.), a natural moraine basin, located in the middle of an impressive relict glacial valley and within a moraine system at the base of the eastern slope of Serra Rocca Chiarano and Serra le Gravare (Figure 3) (Giraudi, 2001).

## METHODS

The geotourism activities and the map of Mount Greco and Chiarano Valley are based on the process of analysis and enhancement of natural and, in particular, geomorphological heritage and on the evaluation of their vulnerability, which are fundamental issues in the analysis of the relationship between human activity and natural processes involving the landscape.

The identification, classification and enhancement process of geological and geomorphological heritage and the geotourism activities are based on the combination of scientific research, an analysis of existing risks and resources, the increase and improvement of tourist facilities and cultural promotion initiatives.

As such, this process is generally aimed at different targets, i.e. tourists, by enabling them to find out more about the park areas; park area residents, by increasing their awareness of the resources, but also of the risks, that can be found in their territory; tourism sector professionals, by developing new opportunities and sustainable ways of exploiting these areas' distinctive features and uniqueness.

The methods are based on a strong scientific and geological knowledge of the territory that comes from a good geological and geomorphological field survey and, consequently, the creation of a geological and geomorphological mapping of the studied areas. This scientific knowledge is then translated into tools for educational knowledge that are mostly based on: (1) three-dimensional reconstructions, aimed at providing a 3D perception of geologic processes and elements; (2) landform highlights, aimed at increasing the perception and identification of landforms and processes, as well as their impact on the landscape; (3) palaeogeographic reconstructions and cartoons, aimed at highlighting the concept of time and landscape evolution. With this approach these tools should provide the landscape's observers with a perception of the geological and geomorphological processes within their spatial and temporal scale, thus allowing them to become aware of the landscape as an evolving feature of the Earth's surface that is the result of the dynamic balance between processes acting from above and from below the Earth's surface itself.

With these tools, the geotourist map and its explanatory notes allow for the geology and geomorphology to be presented in a simple and educational way written for children, teenagers and adults, going back over a history wrote during millions of years. In this way, the map represents a business card, useful to discover and enjoy a wrapping and spectacular nature and beautiful tourism oasis, using geological contexts or peculiarities as key elements to develop tourism in less-familiar areas.

## THE GEOTOURISM IN THE MOUNT GRECO AND CHIARANO VALLEY AREA

Within the Abruzzo, Lazio and Molise National Park geotourism activities, tools and products are recently spreading (Miccadei et al., 2010, 2011, 2013; Sammarone et al., 2013) and an example is the Geotourist map of Mount Greco and Chiarano Valley. This map illustrates different landscapes and landforms related to different rocks and geomorphological processes affecting the area (Figure 4).

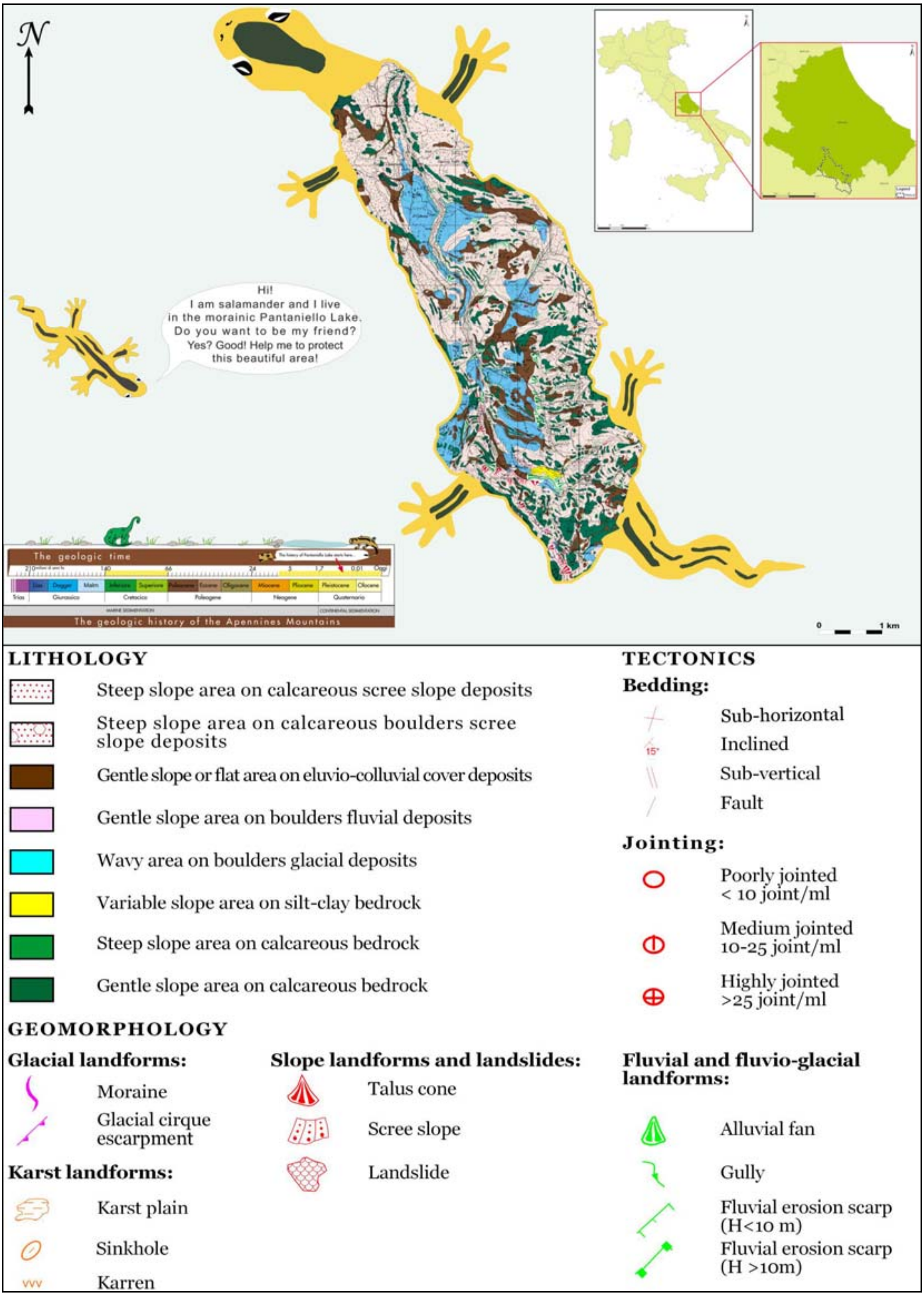


**Figure 4**. Geotourist map of Mount Greco and Chiarano Valley

Geological and geomorphological processes, still active, contribute to, continually, change the landscape and allow us to observe beautiful calcareous scree slopes which dominate the Mount Greco and Chiarano Valley slopes. The valley bottom is marked by pastures, high-altitude meadows and beech woods (D'Angeli et al., 2011 *a*, *b*). The valley systems of Pistacchia Valley and Cupa Valley and Chiarano Valley show well preserved remnants of a relict glacial morphogenesis and landscape.

The area is characterized by a set of calcareous ridges incorporating a very complex geological history started millions of years ago. Sediments forming the calcareous rocks were deposited in ancient shallow to deep seabed (pre- and sin-orogenic deposits, Triassic-Miocene, 250-20 million years ago). Calcareous rocks constituting the ridge are typical of slope paleogeographic environment between shallow water Bahamian-like carbonate platforms and deep-sea pelagic environments.

These calcareous rocks show a variable jointing and constitute the bedrock of the main mountains and peaks showing gentle to steep slopes (i.e., Mount Greco, Serra le Gravare, Mount Pratello, etc.). Spots of syn- and late-orogenic Neogene pelitic-arenaceous rocks are also present, constituting the bedrock of variable slope areas in the lower part of the valleys.

Since Miocene time, compressional tectonic activity followed by strike-slip tectonics (Pliocene) and regional uplift with extensional local tectonics (Late Pliocene – Pleistocene), has been responsible for the formation of the Apennines mountains and Adriatic piedmont areas. The emergence of the chain has induced continental sedimentation of post-orogenic deposits in a newly forming land, the peninsular Italy. In the Mount Greco and Chiarano Valley, these sediments were deposited in different environments, variable and repeated over time, such as: scree slope, karst, fluvial and alluvial fan, glacial and cryonival.


**Figure 5** – Stazzo Pantaniello (1830). Glacial erratic boulders on the gentle valley bottom

The resulting deposits are scattered on the slopes and cover the valley bottoms. Scree slope, fluvial and alluvial fan deposits are present at lower elevations (i.e., below 1400 m a.s.l.), while glacial and cryonival deposits, locally covered by scree slope deposits, are largely present at the highest elevation as large relict remnants of ancient glacial landscapes which several times affected these mountains during Pleistocene age (Cinque et al., 1990; Colacicchi, 1964; Damiani & Pannunzi 1987, 1991; Giraudi, 2001, 2004; Giraudi & Frezzotti, 1997).

Glacial and cryonival deposits are made up of heterometric calcareous boulders, with a variable percentage of silty-sandy matrix, arranged in a chaotic setting and forming elongated moraines. They characterize gentle and wavy patches on the landscape, mapped in the eastern flank of Serra le Gravare ridge (Figure 5).

Fluvial deposits are composed by well-rounded calcareous gravel, cobbles and boulders with sand lenses and are present all along the Chiarano Valley.

Eluvial-colluvial deposits cover gentle slope or flat area along the eastern part of Pantaniello Lake basin.

Scree slope deposits are formed by calcareous, heterometric, angular gravel and cobbles, locally with small to large boulders, and with sandy-clayey matrix only on arenaceous pelitic bedrock. These deposits are scattered in the whole area, also at high elevation, forming talus cones or scree slopes on calcareous bedrock or on ancient glacial deposits (Figure 6).

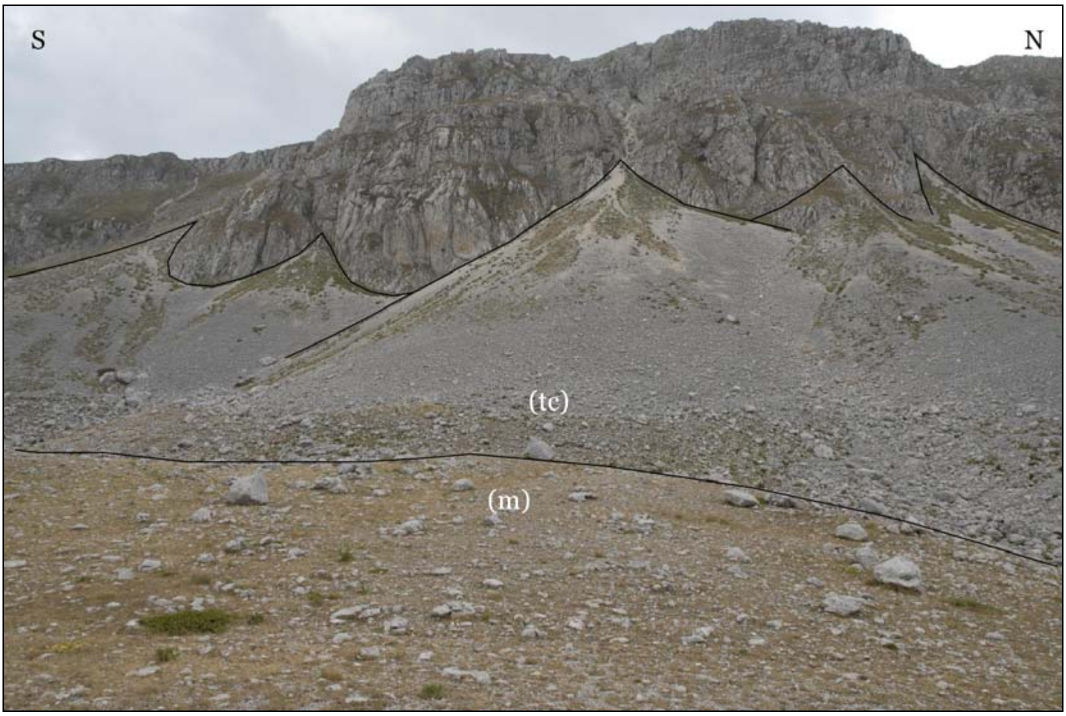


**Figure 6** – Mount Greco -St.zo Ospeduco (2071 m a.s.l.). In the foreground, glacial deposits boulders (m); in the background, calcareous scree slope deposits forming talus cones (tc) developed from a bedrock escarpment and covering ancient glacial deposits

Structurally, the Mount Greco and Chiarano Valley area shows a faulted homocline setting with NNW-SSE orientation and NE dipping. The south-western side of the structure, however, shows a slightly opposite SW dipping. The overall structure is very complex because it is composed of several small to large homoclines separated by subvertical faults with orientation from NW-SE to NNW- SSE. The main fault planes affecting these homoclines show NNW-SSE orientation, sub-vertical geometry and evidence of strike-slip horizontal movement (Pantaniello Lake). In some spots, pelitic arenaceous rocks are squeezed along these fault planes, testifying for a complex tectonic history (Stazzo Ria, Pantaniello Lake), (ISPRA, 2010; Miccadei et al., 2012).

The landscape of Mount Greco and Chiarano Valley area is composed of several types of landforms resulting from a wide range of geomorphological processes: glacial landforms, karst landforms, slope landforms and landslides, fluvial and fluvio-glacial landforms.

Glacial landforms, both erosive and depositional, are the result of Pleistocene cold stages on landscape. Here, they are clearly evident all around the highest peaks and ridges, as in the case of Serra Rocca Chiarano where several glacial cirques scarp are preserved, slightly weathered by slope processes.


**Figure 7.** Monte Greco-St.zo Ospeduco (2014m a.s.l.). In the foreground, moraine covered by more recent slope deposits; in the background, glacial cirque escarpment

Within the biggest glacial cirques depositional landforms, lateral, ground and terminal moraines, are preserved, frequently covered by more recent slope deposits (Figure 7) and locally related to rock glaciers (Giraudi, 2002). All along the Chiarano Valley moraine landforms outline a humps and bumps landscape. Within this landscape, one of the most beautiful tourist destinations in the Peligna region and within Mount Greco and Chiarano Valley area is Pantaniello Lake (1818 m a.s.l.). This small mountain lake is the result of the damming of "*U*" shape glacial valley due to a small moraine arch (Figure 8). At the highest elevation (Serra Rocca Chiarano) are also present periglacial landforms and deposits, such as patterned ground and block slopes deposits (Chelli et al., 2006).

Slopes and ridges on calcareous bedrock are also characterized by widespread karsts landforms. On the slopes of Pantaniello Lake basin calcareous sculptures are shaped by water erosion and dissolution forming several micro and mesoforms, such as dipslope small incisions (karren fields, from the German Karrenfeld), channels, holes and cavities, with sub-circular or elliptical shape, widespread on Toppe del Tesoro o Piano Polverino. Among the karst macroforms sinkholes are present (Serra le Gravare and Toppe del Tesoro slope), small depression within plains, slopes and dolines, in which surface water flows into the highly jointed and permeable calcareous bedrock.

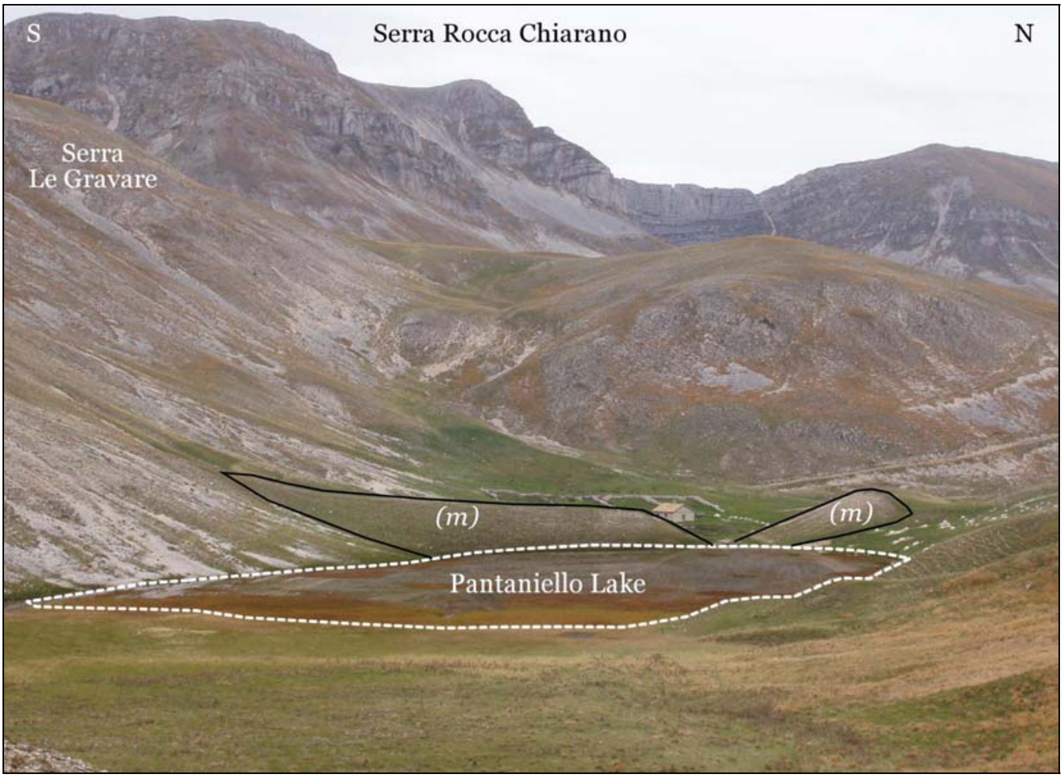


**Figure 8**. Pantaniello Lake. Morainic lake dammed by a moraine (*m*) transversal to the main valley at the base of the Serra Rocca Chiarano eastern side and Serra le Gravare slope.

Finally, ridges' slopes are also affected by slope processes due to gravity in combination with water and frost weathering (Figure 9). Talus cones and scree slopes are produced by the accumulation of calcareous angular gravel and cobbles and large boulders at the slope base or along valleys and canyons. These landforms are present in the Serra le Gravare area and at the slope base that surround Pantaniello Lake. Locally, the area is also affected by landslide locally developed pelitic-arenaceous bedrocks.

## CONCLUSION

In Abruzzo, the region of Parks par excellence and a 'green lung' of Europe, the enhancement of geomorphological themes for educational purposes has been pursued through the creation and installation of information panels and geological and geomorphological itineraries. The geological heritage, which is deeply rooted in the region and to date only accessible to a limited number of experts, now needs to be introduced to a wider audience, sensitive to earth and environmental dynamics and interested in the protection and the preservation of heritage. The correct classification of natural and, in particular, geomorphological heritage, its geodiversity and the evaluation of its vulnerability are fundamental issues in the analysis of the relationship between human activity and natural processes involving the landscape. A contribution to the identification of new geotourist area is provided here with the implementation of geotourism activities.

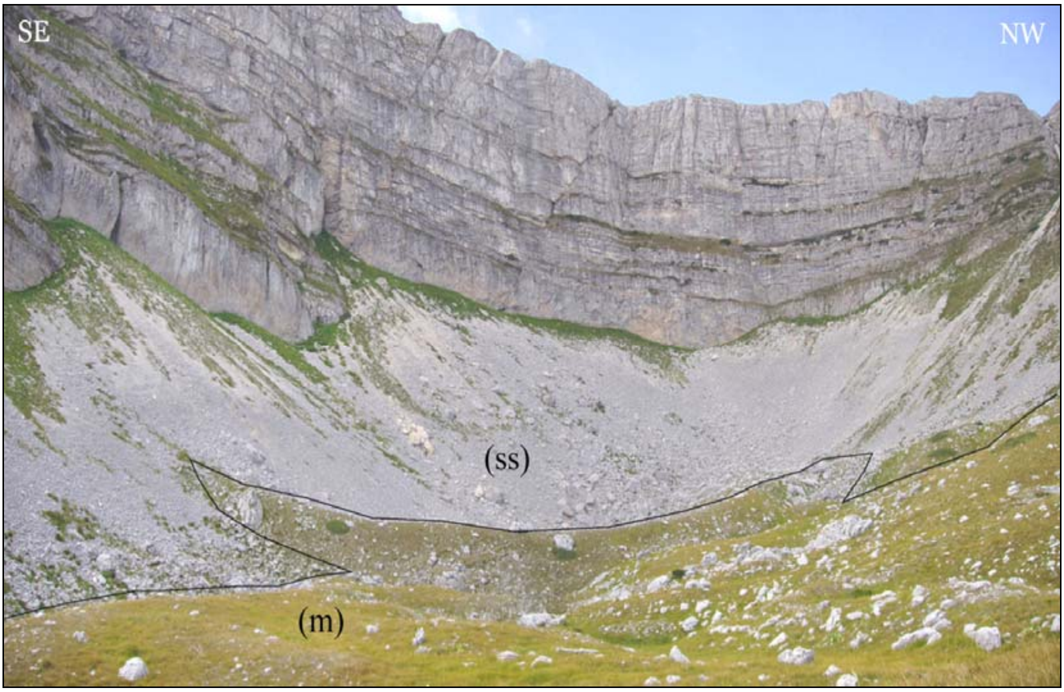


**Figure 9.** Serra Rocca Chiarano (2200 m a.s.l.)
In the foreground, glacial deposits boulders (m); in the background, calcareous scree slope deposits (ss) forming scree developed from a bedrock escarpment

Within this framework, this paper presents landscape and landforms enhancement methods and tools for the promotion of geotourism in the Abruzzo area and in the Abruzzo, Lazio and Molise National Park, through a geotourism map.

Main objective of the map is to enhance the geological heritage of Mount Greco and Chiarano Valley an awesome landscape in the surroundings of Abruzzo, Lazio and Molise National Park explaining the meaning of different types of landforms resulting from ancient glaciers, present slope processes, or slow karst dissolution. This in order to make people aware that the present day landscape (i.e., a lake, a valley, a ridge, a landslide, but also a rock, a fracture, or a small hill) is the result of a thousands to millions to hundreds of millions of years of a dynamic evolution ongoing until now and towards the future.

The Mount Greco and Chiarano Valley area has a strong landscape value, representative of the water cycle over geological time and expression of the

Quaternary age processes, ancient, glacial morphogenesis that characterizes the landscape of Pantaniello Lake, slow, karst dissolution, fast, slope processes. Through the comprehension of the present landscape it is possible to explain to the public (from very young to aged) the geological history written in rocks and landforms and to make people aware of the very high dynamics of the landscape, which provides outstanding landscapes but also natural hazards and risks.

Geotourism maps, as well as other geotourism tools, are targeted at various potential users, tourists, local residents, young people, schools etc., and are aimed at the enhancement of geological and geomorphological features. With this approach they provide the landscape's observers with a perception of the geological and geomorphological processes within their spatial and temporal scale.

This approach to the enhancement of landscape based on the direct observation of landform and processes could be applied and reproduced within other park areas and local reserves in the Abruzzo region and could also provide an example at the national and international level. The realization and circulation of these maps and tools in the all Park areas will induce a deeper appreciation of the territory's beauty linked to a natural awareness of the landscape as an evolving feature of the Earth's surface resulting from the dynamic balance between processes acting from above and from below the Earth's surface itself. This will greatly improve the general public's awareness of natural resource value and of natural risk significance resulting from natural processes in an evolving Earth.

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# THE ROLE OF ARCHAEOLOGICAL LANDSCAPE RESTORATION IN BUILDING THE LOCAL TOURISM IMAGE: THE GUMELNIȚA ARCHAEO - PARK (DRĂGĂNEŞTI - OLT, ROMANIA)

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**Abstract:** The study is based on the current global trend of archaeo-landscape studies aimed at reconstructing some relevant sites through experimental archaeology and encouraging their use for scientific and tourist purposes. In the town of Drăgăneşti-Olt, due to the involvement of local authorities and the Boianu Plain Museum, a Gumelniţa Culture tell site was reconstructed. The study aims to establish if this unique Romanian archaeo-park can build the cultural identity of the town, assuring the foundation for building a local tourism image. Methods used were based on field research and survey as a tool to analyse people's perception. The data was processed in QSR NVivo 10. The archaeo-park is currently unique in Romania and the several reconstructed pile dwellings depict the living conditions of the Neolithic era. Each detail is based on the rigorous archaeological research and discoveries in the nearby tell, also sharing common features and elements with similar settlements in Europe. The results of semi-structured interviews show that most of the respondents view the museum of Boianu Plain as the regional center of interest, a major element of the town tourism identity. Consequently, townspeople consider it useful for educational tourism or scientific interest, but it needs serious efforts to market it as a cultural image of the town along with Boianu Plain Museum.

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**Key words:** archaeological landscape, archaeo-park, pile dwellings, tourism identity image, Gumelniţa, Romania.

* * * * * *

**INTRODUCTION**

Every place has a more or less important history. Bringing to the fore the most valuable past elements through conservation, reconstruction, and promotion helps the development of local destinations and the emergence of symbols that combined with others form the national heritage.

International tourism literature argues that history provides resources for cultural heritage tourism and serves as an exploitable resource base for wide range of high-order economic activities (Ashworth, 1994).

Cultural tourism based on marketing, exchange of knowledge, and introducing the heritage of a place to visitors becomes an activity that allows its economic valorization and also spreads local culture to other social and spatial levels.

In fact, Palmer (1999, p. 10) highlights that "*tourism's use of identity goes far beyond the commercial; it goes to the heart of a people because it serves to define their cultural identity and to make this visible, both to themselves, and to 'others'. Furthermore, cultural identity underpins national identity as it communicates the past and present traditions and mores of a people, thus enabling them to be identified as a distinctive group*".

The current trend of archaeological landscape restoration illuminates a part of history and can help build the cultural heritage and identity of a place (Iorgulescu et al., 2010) and sometimes of a nation. The study of archaeological landscapes is focused on the history of landscapes, the policy of preserving archaeological sites and landscapes, the reconstruction of some of them through experimental archaeology, and their use, first for scientific and then for tourism purposes, which can revitalize certain areas by creating new jobs locally and regionally.

The definition of archaeo-landscapes as natural landscapes modeled and/or adapted to life needs by humans in the past was developed by experimental archaeology, simply defined as "*the response to objects, habits, and processes from the past*" (Mathieu, 2002, p. 1). This science has allowed Archaeologists and other specialists to reconstruct and test some of their ideas about the past. Starting from Darvill's assumption that "*looking into our own past is like looking into the future of other societies*" (Darvill, 1996, p. 192), the scope of such experiments varies largely. Many experiments included the construction of houses of various types from different historical periods, including the reconstruction of Iron Age farms that were furnished with appropriate livestock, arable land, and all the necessary conditions to maintain an independent life (Palmer et al., 2009, p. 10).

One of the benefits of experimental archaeology is that it provides a means by which we can visualize the interpretation of what happened in the past (Palmer et al., 2009, p. 10). In Europe, 111 out of 937 archaeological sites around the Alps reveal almost intact wood structures in prehistoric pile-dwellings of outstanding value for humanity. They were therefore included on the UNESCO heritage sites list in 2011 (UNESCO, 2011)[1]. A few of these sites were reconstructed and function as open air museums, for example, Wauwil near Luzern in Switzerland and Unteruhldingen near Lake Constance in Germany (Schöbel, 2010).

[1] Details on URL: http://whc.unesco.org/en/list/1363/

Among other valuable long-term experiments, those conducted at Lejre near Roskilde[2] in Denmark and at Butser near Petersfield in England can be cited.

At Lejre, an experimental archaeology center was established in 1964 on an area of 43 hectares that recreates an Iron Age village with houses, household annexes, and workshops, a Stone Age settlement, a Viking market, and a 19th-century farm surrounded by pastures with grazing herds of animals, gardens, ponds, and woods. The Center for Historical and archaeological Research and Communication or "*Lejre, Land of Legends*"[3] is visited annually by tens of thousands of tourists and archaeologists, ethnologists, anthropologists, and students (Palmer et al., 2009, p. 10).

The Butser Ancient Farm (Palmer et al., 2009, p. 10) is located near Petersfield in Hampshire, southern England (Reynolds, 1979; Foweler, 1983). It has a number of buildings that recreate the prehistoric Iron Age[4], and the site is used both for tourism and activities by experimental archaeology specialists. The farm is open to the public and special events take place here throughout the year (Reynolds, 1999).

In Romania, experimental archaeology is still in its infancy, but there have been attempts in this regard such as the Vădastra experiment in the village of the same name in Olt County (Gheorghiu, 2008). In this village, several Neolithic houses were built from wood and clay as well as some pottery kilns for experiments in modeling, decorating, and firing ceramic vessels. Activities in the field of experimental archaeology were also conducted by the Alexander Ioan Cuza University from Iaşi, in Cucuteni, specifically the reconstruction of Neolithic houses and ceramics (Cotiugă & Cotoi, 2004; László & Cotiugă, 2005).

Another project was located in the town of Drăgăneşti-Olt where an archaeological park has recreated the Gumelniţa culture of the area. The main purpose of the reconstruction undertaken by the Boian Plain Museum was a scientific experiment, but the possibility of exploiting the site for tourism use arose since the site was maintained.

In Romania, the range of the Gumelniţa culture generally corresponds with the Boianu culture in Wallachia but extended into Dobrogea on the territory previously occupied by the Hamangia culture and into the southern Republic of Moldova. In Bulgaria it occupies the eastern half of the territory both north and south of the Balkan Mountains (Comşa, 1987).

The specific elements of this culture include a multitude of tell settlements located on islands reinforced or not with defense systems and invariably built around artificial and natural water sources and easily exploitable natural resources: water, land suitable for agriculture and livestock, and hunting, all combined to comprise a class of human relationships with the environment (Comşa, 1987). A tell is a specific type of Neolithic settlement and, to a lesser extent, of the Bronze Age, that has the appearance of a mound artificially formed by successive deposits of anthropogenic debris.

Such sites are registered among museums whose role is to research and conserve but also to encourage educational and cultural tourism.

## STUDY AREA

Drăgăneşti-Olt is a small town on the western Boianu Plain, a subunit of the Wallachian Plain, located at the base of its rim on the Olt River flood plain (Figure 1).

The original Neolithic tell in Drăgăneşti-Olt is located in the peripheral area of the Bâzărani neighborhood on the right bank of the Sâiu stream on the Olt River flood plain (Butoi & Zorzoliu, 1992, p. 73) (Figure 2). The settlement overlayed a mound built of

[2] For further information see: URL: http://www.roskilde.com/cmarter.asp?doc=2978
[3] More details on URL: http://www.sagnlandet.dk
[4] For more see: URL: http://www.butser.org.uk

point bar deposits, but had no defensive mud wall, normally a feature of the Gumelniţa Culture – Neolithic sites (Figure 3). The profile in Figure 4 indicates the detailed geomorphic features of the area where the islet was surrounded by a marsh (Corboaica Marsh) that existed here until 1950 when land reclamation work and the cultivation of rice began (Nica et al., 1995, p. 15). This explains the absence of moats at this tell, which was protected for millennia by the marshes of the Sâiu stream (Nica et al., 1995). The layer thickness exceeds three meters. Between 1982 and 2005, seven archaeological campaigns were conducted, and the excavations revealed that this tell settlement contains archaeological material belonging to both Gumelniţa-Sălcuţa and Glina cultures since it falls between them. Measurements of the surface indicated that the settlement had an ellipsoidal shape with a maximum 120-meter diameter (Butoi & Zorzoliu, 1992). The tell comprises three major periods of occupation, and the archaeological material reflects the lifestyle of these communities in 5,000 to 4,000 BC. The Drăgăneşti-Olt restoration is not achieved *in situ* but inside The Boianu Plain Museum (Figure 2).

**RESEARCH METHODOLOGY**

The proposed targets were based on research of the literature, direct field observations, and socio-statistical techniques including semi-structured interviews using coding data by QSR.NVivo 10 software (Rubin & Rubin, 2005). Several visits were made to the area between 2010 and 2012 for direct observations, taking photographs, and conducting interviews with local authorities, the managerial team of the Boianu Plain Museum, local people, and tourists. Inline with the deontology of interview applying we obtained the approval of using the demographic data of each respondent and consequently we code them. QSR.NVivo 10 software allowed us to make nodes for each respondent's opinion regarding the 10 addressed questions and analyze the relationships between the demographic characteristics of the interviewed sample, draw the word query which gave us the frequency of words and group all of them by words similarities.

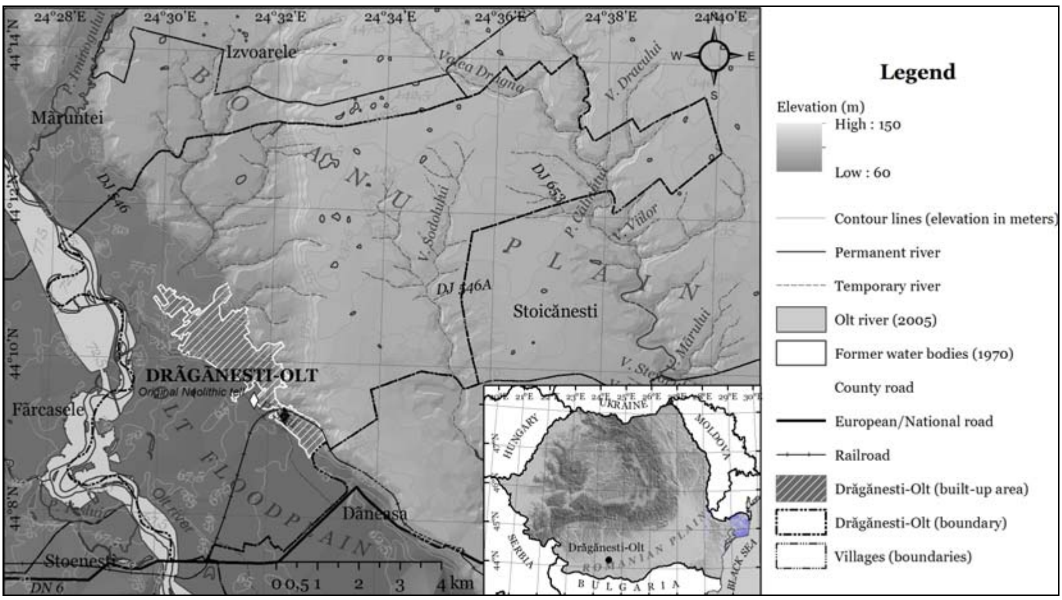


**Figure 1.** Geographic setting of Drăgăneşti-Olt town
(SRTM data for the map in the vignette, DEMs by authors)

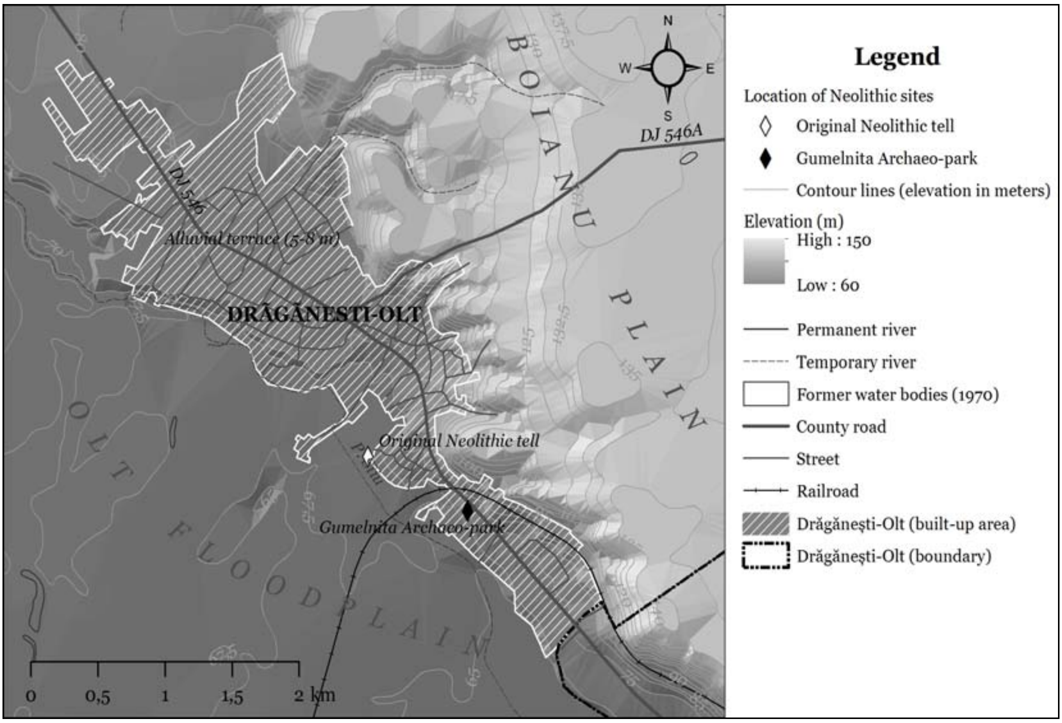


**Figure 2.** Location of the Neolithic tell and Archaeo-park in Drăgăneşti-Olt

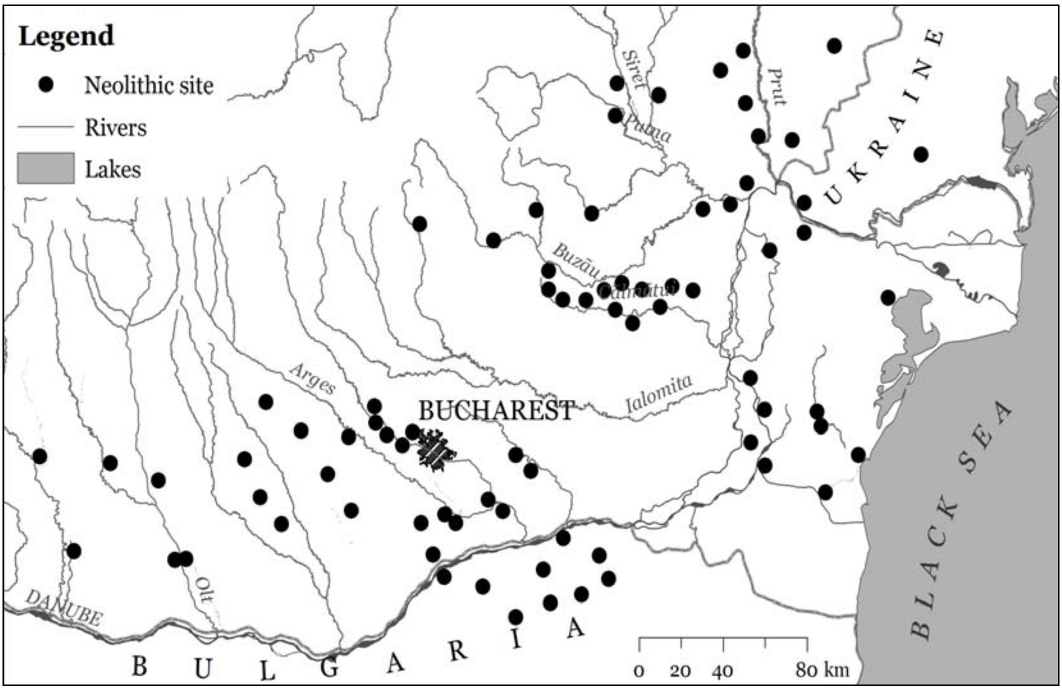


**Figure 3.** Gumelniţa Culture Archaeological sites
(Source: CIMEC map, processed after: http://www.cimec.ro/Arheologie/gumelnita/3arii/main.htm)

The Pearson's correlation analysis was used to illustrate the respondents' profiles. Respondents' age and occupation were the two input variables. Generally, the index value -1 shows no correlation and value of 1, a strong correlation. The results are referred to as nodes and output on a 3D graph as columns.

The maps and geomorphic profile in Figures 2, 3, and 4 were created using GIS techniques (in Global Mapper *v.9.x* and ArcGIS *v.10.x* applications) in order to precisely locate the *in situ* Neolithic settlement and its accurate reconstruction inside the Boianu Plain Museum. To obtain the different layers, we used topographic map 1:25,000 (1970), orthophotographs with resolution of 0.5 m (2005), and SRTM data (source: USGS, University of Maryland). The reference system used is UTM/WGS84. The Gumelniţa site data was collected from www.cimec.ro.

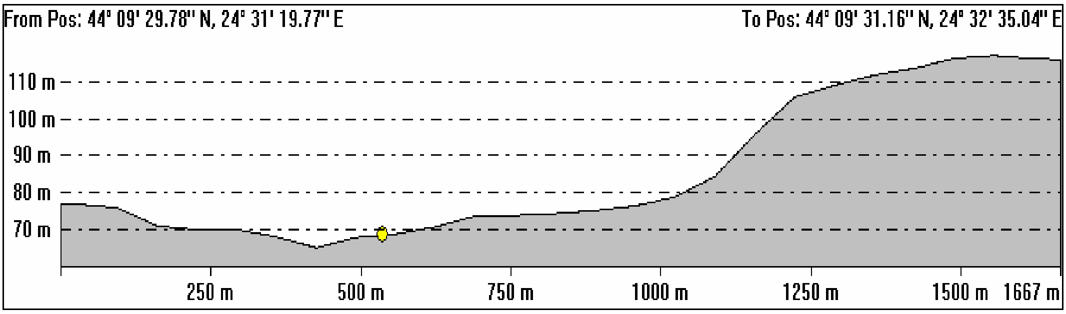


**Figure 4.** Cross-section of Olt flood plain and rim of Boianu Plain showing location of the original Neolithic tell (geomorphic profile created with Global Mapper)

Research hypothesis: the Drăgăneşti - Olt Archaeological Park presents a piece of Romania's heritage and is an attraction of cultural value that could represent the town's tourist identity and make it more visible in the tourism offer.

In order to test the hypothesis, the study was structured in four parts corresponding to the following objectives: presentation of a recovery model through experimental archaeology on a tell settlement in Drăgăneşti-Olt, Olt County; identifying the main forms of tourism and relevant target groups; exploring methods of promoting this cultural and historical site; analyzing the community perception about the Gumelniţa Archaeo-park as a part of Boianu Plain Museum as a symbol of the town's tourism identity.

## RESULTS AND DISCUSSIONS

### Presentation of a recovery model through experimental Archaeology on a tell settlement in Drăgăneşti-Olt, Olt County

This archaeo-park is currently unique in Romania and is among the few reconstructions of this type in Europe. It presents the typology of housing, the layout of houses, household inventory, and tools used for pottery, fishing, hunting, and agriculture.

The park is a reconstruction of a Neolithic village street that shows the manner of development specific for Neolithic settlements, starting with a small group of dwellings and gradually adding others as the population grew. The reconstituted village consists of life-size huts in a natural setting on land surrounded by a moat and a wattle fence and seeks to replicate the historic landscape as closely as possible (Figure 5).

Entry to the village is across a wooden bridge constructed over a stream. One of the huts is a fisherman's house where several fish are hung to dry beside the door along with a fishing net and fish scales lie scattered in front of the house.

A farmer's house is surrounded by tools used in the fields and exposed to the elements, including hoes and scoops made of antler. There is also a potter's house and a grave specific to this culture, an oval hole containing a skeleton with its legs and arms folded against the chest.

The village has a pile building with wooden shelves used for storing supplies, necessary because these ancient settlements were built in frequently flooded valleys.

**Figure 5.** The entrance to the Gumelniţa Archaeo-park, Drăgăneşti-Olt
(Source: Iuliana Vijulie)

**Figure 6.** A pile dwelling
(Source: Iuliana Vijulie)

**Figure 7.** Entrance porch
(Source: Iuliana Vijulie)

A stilt house or pile dwelling made of wattle was reconstructed in the village (Figure 6) and a corral where people kept their animals. According to studies on the Gumelniţa Culture in the study area (Nica et al., 1995) and the reconstruction of the Gumelniţa Archaeo-park in Drăgăneşti-Olt, Neolithic dwellings were rectangular, often consisting of one or two rooms. Some houses were also provided with an entrance porch (Figure 7).

**Figure 8.** The inner design of a hut: a. room; b. loom; c. pottery on rudimentary shelves; d. clay bed covered with a mat or woolen woven blanket (Source:Iuliana Vijulie)

The roofs were made of straw or reed with two or four sides. The buildings were low because the people did not exceed 1.50 to 1.60 meters in height and had round or oval windows that probably were covered with wattle gratings. The walls were made of poles tied with cane and covered with clay mixed with chaff. Each hut was fitted inside with a fireplace for food preparation, an oven, a loom, and rudimentary furniture (shelves, tables). The bed was built from clay and covered by mats made from lake plants (Nica et al., 1995) or simply animal skins (Figure 8).

The floors were made of clay or beaten soil. The walls of the houses were mostly painted using natural pigments from the Gumelnița area (Figure 9).

The reconstruction of the tell offers an understanding of how the life of the past populations was organized, the housing typology, the arrangement of houses, household inventory, and the tools used for pottery, agriculture, fishing, and hunting.

**Figure 9.** Hut walls painted in natural pigments (Source:Iuliana Vijulie)

**The Gumelnița archaeo-park and the tourist market**

Beyond its strictly scientific achievements, the park is a local and even national sightseeing destination. Although the town is on the Bucharest-Timişoara railway line, its location five kilometers north of the E70 highway means access by road is somewhat inconvenient. Given the two and a half hours needed to drive from Bucharest and the forty-minute drive from Slatina on the E65 highway, the flow of tourists is small. Furthermore, the town has no accommodation facilities.

According to the Boianu Plain's authorities, despite the park's recent establishment, the volume of visitors is around 5,000 yearly with two peaks in September and April due to school visits. The guests have included Romanian visitors (students, archaeologists, ethnologists, anthropologists, geologists, geographers, etc.), transit tourists, and tourists from the United Kingdom, Germany, the Republic of South Africa, and Moldova.

The informative content of the Gumelniţa Archaeo-park is suitable for several forms of tourism: educational, scientific, cultural, and event tourism as well as transit tourism. Students, who comprise the largest category of visitors, come primarily from local schools in Olt County or neighboring counties. The first "*scientific*" tourist event occurred in September, 2010, was part of a trip for participants of the International Aerial Archaeology Conference organized by the international Aerial Archaeology Research Group (AARG) and the Institute for Cultural Memory (CIMEC). Tourist events can be held in the context of Gumelniţa Day and include book launches and cultural activities of various NGO's.

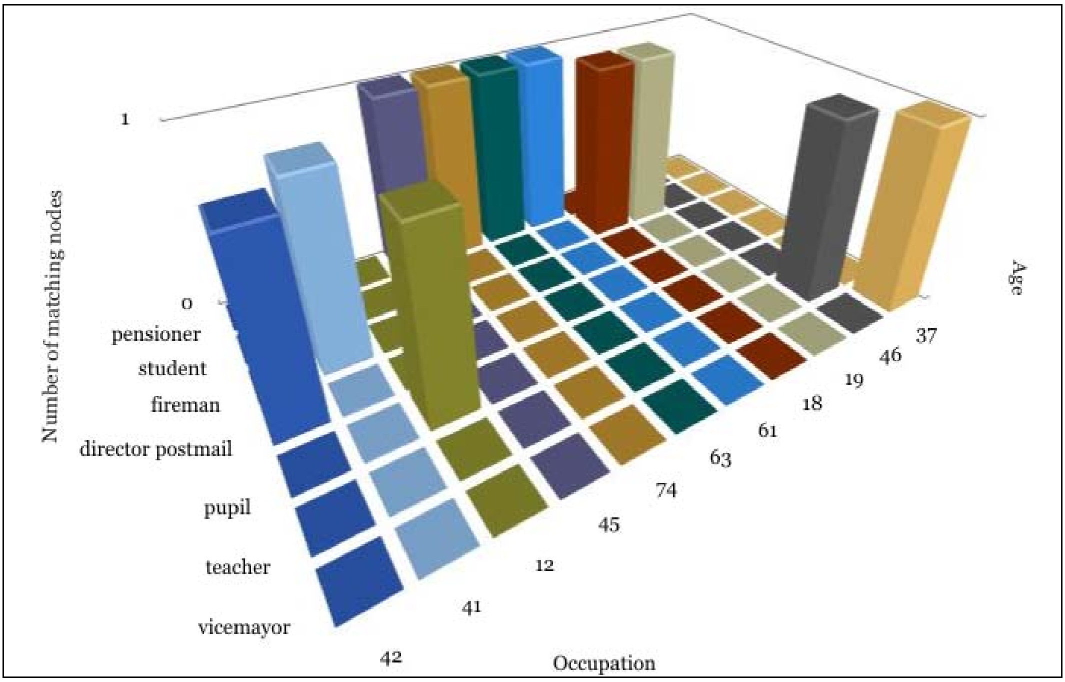


**Figure 10.** The respondents' profiles: Pearson's correlation between age groups and occupations (Source: QSR NVivo.10 output)

The administration of the Boianu Plain Museum also proposes using its Neolithic settlement as the starting point of a package tour to Archaeological and historic sites in Olt County, a plan that is quite feasible at this stage. The circuit will run about eighty kilometers and include other area attractions such as the Titulescu Complex Museum, the Museum of Post Chaise in Şerbănesti, the Museum of Military Priests in Radomireşti, the Firefighters Museum in Drăgăneşti-Olt, and the Dacian artifacts in the Sprâncenata museum. Another project aiming to increase tourist interest in this area will link the Boianu Plain Museum to the Romanian *"Căluşului"* Museum (folk dance included in the UNESCO heritage list) and the Ethno-folk revival complex in Stoicăneşti which contains several rare objects and buildings including a church hut.

**The Boianu Plain Museum – a symbol for the town identity in the community perception**

Given that the Boianu Plain Museum contains the Gumelniţa Archaeological site and its uniqueness in Romania's cultural tourism offer, we hypothesized that it could become the symbol for the town identity and subsequently the town's tourist image. To test this hypothesis we constructed a pilot questionnaire in cooperation with the museum staff in order to conduct a semi-structured interview with eleven participants from the local community. The sample population included all the age groups and various occupations and was divided into 54% female and 46% male corresponding to the socio-demographic structure (NSI, 2008) of the town.

The respondents' profiles were analyzed using Pearson's correlation. The results are output in the 3D graph in Figure 10, with positive values of Pearson's index ($I_P = 1$). The nodes reveal a strong correlation between respondent's age and occupation (Figure 10), which is related to the quality and accuracy of the answers given.

All the respondents allowed us to use their answer for scientific purpose. In this respect we coded each participant giving a symbol "*M*" (male) plus a number (1...5) and "*F*" (female) plus a number (1...6) and tallied each answer. This helps us to introduce all the information using codes in QSR NVivo 10 software and then we classified them and used queries for descriptive statistics (Welsh, 2002). Despite the answers matching the image of the town with various buildings or natural sites, almost 50% of the respondents' conversations mentioned the town museum as a major element of the town tourism identity, considering it very interesting and beautiful. The word frequency query (tree map, word query) made with the NVivo software confirmed our hypothesis showing that the word "*museum*" had a frequency about 6% from the first one thousand words analyzed (Figure 11).

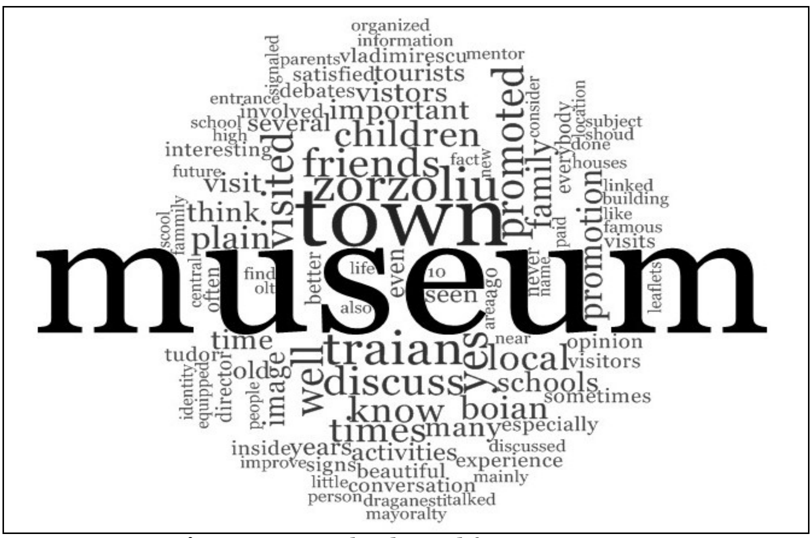


**Figure 11.** Tag cloud.Word frequency query
(Source: QSR NVivo.10 output)

To highlight the result of the word frequency query we asked the software to cluster the interviewed persons and obtained two large clusters, one very developed that includes many subgroups (pupils and teacher, the vice-mayor and a pensioner, both women, etc.) and one made up of pensioners (Figure 12).

In order to continue our research and test how strong this image could be for the town, we collected answers about its importance in topical conversations among respondents within friends and families, which showed that while the museum is not generally a subject of conversation within families, it is often discussed outside the home (63%). Furthermore, all of them had visited the museum between one and ten times, while two revealed a genuine community spirit by being involved as volunteers in the museum's endowment activities by collecting donations and donating artifacts.

To build an identity image of the town for use in tourism, our field observations indicated the vital importance of signing and promotion. While obviously the town is small in terms of area, population, and economic output, the museum does not benefit enough from a good strategy of promotion and signing. Thus, the respondents' opinions on organizing at the territorial level, which includes visible means of providing information, are divided: some believe there are enough signs near the museum or on the E70 highway, others suggest augmenting local bus routes and bus stops to provide easier access the tourist landmark, and all of them recognized the lack of promotion through any of the available marketing channels. As the respondents' recommendations indicated, the necessary next steps in building an identity image of the town based on the museum include increasing the flow of tourists, who are generally perceived as being favorably impressed with the contents of the museum and especially by the Gumelniţa site; improving the promotion of the museum, and integrating the spatial planning for the museum and the town with the deep involvement of the mayor in the process.

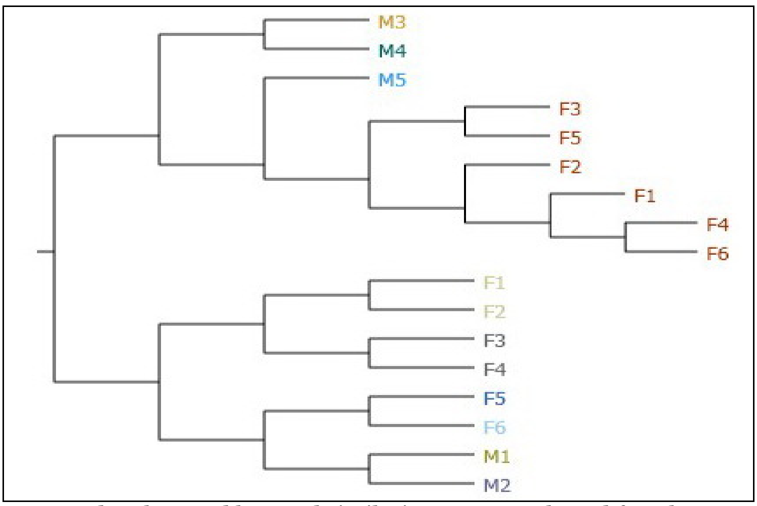


**Figure 12.** Nodes clustered by word similarity among male and female respondents
(Source: QSR NVivo.10 output)

## CONCLUSIONS

As a result of the research activities, it can be said that even though the Gumelniţa site is unique in the country, the townspeople did not consider it a tourist attraction other than for educational tourism or scientific interest.

Its position, somewhat distant from popular tourist destinations, and its small effect size compared to an amusement park like Disney Land make it unknown on the tourist market. In its current state and form as part of the Boianu Plain Museum, it can contribute together with the entire museum to establishing the town's tourist identity image, but as most residents largely recognize, it needs a serious marketing effort and smart promotion.

In an era in which information spreads so quickly and can be easily accessed with a computer, museums are finding it increasingly more difficult to attract visitors and are therefore obliged to offer more than just a few exhibits in a window. Under these circumstances, the impact produced among potential tourists who are interested in the visual (aesthetic) aspects of reconstructing the past and see a restored Archaeological landscape could help, but the museum needs more than a website, including the possible establishment of a Gumelniţa tell network.

Capitalizing on a country's or region's Archaeological heritage is a difficult task. However, despite the time and financial commitment necessary, reconstructions of historic landscapes such as the Drăgăneşti-Olt tell will be the future method for museums to present the past.

Until now, this Neolithic settlement has been appreciated and promoted individually on a small scale but could easily be included in a medium-scale museum circuit. The proposed objective of the Boianu Plain Museum is to use its Neolithic settlement as the starting point of a package tour to Archaeological sites and historic sites in Olt County, which is a feasible plan at this stage. The proposed circuit will run about eighty kilometers and include other area attractions such as the Titulescu Complex Museum, the Museum of Post Chaise in Şerbăneşti, the Museum of Military Priests in Radomireşti, the Firefighters Museum in Drăgăneşti-Olt, and the Dacian artifacts in the Sprâncenata museum. The future inclusion of the Romanian "*Căluşului*" Museum and the Ethno-folk revival complex in Stoicăneşti that the local authorities propose, plus accommodation facilities development will further support the increase of tourist interest in this area.

**Acknowledgement**

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# MAP OF THE NATURAL AND CULTURAL HERITAGE IN THE LANDSCAPE OF THE CARIGNANO WINE DISTRICT OF THE SULCIS REGION (SW SARDINIA)

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**Abstract:** "*Carignano del Sulcis*" is a much appreciated wine, ruby red with a dry, sapid and harmonious flavour. It is produced exclusively from vineyards trained as alberate and trellised alberate. The area of production, which includes all administrative territories of many Sulcis communities, features a complex and varied landscape from the geological and geomorphological standpoints. It has a high degree of geodiversity and density of sites of great geomorphological and landscape interest whose salient characteristics are described below. The work presents the results of an inventory of the natural (geosites, geomorphosites, parks and nature reserves) and cultural heritage (archaeological sites, industrial archaeology sites, sites of architectural, historic and traditional interest) classified and georeferenced within their landscape units, together with a part of the wine-producing areas. From the overall picture of the heritage emerges a high degree of multiplicity of the natural and cultural heritage that may play an important role as a possible motor for truly sustainable development from the standpoint of geo- and cultural tourism more in general.

**Key words:** landscape, geosites, cultural heritage, Carignano wine, Sulcis.

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## INTRODUCTION

### Objective of the study and methods of investigation

This work proposes an analysis of the distinctive features in the soil of "*Carignano del Sulcis*" vineyards (Figure 1). To this end, a careful investigation of its

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geological and geomorphological nature was performed. It involved the retrieval of knowledge acquired by several authors and the use of existing official geothematic maps (APAT, 2009, 2012; Assorgia et al., 1992, 1992a). The investigation was carried out by direct inspection and aerial photo interpretation at different scales to map not only the main vineyards, but also the main physical features of the landscape. The sites of geological and geomorphological interest were also studied through field survey with special features by means of which it is possible to analyse and identify the territory geological history, the evolution of its landscape features and the processes that have moulded them.

With the same approach similar studies were performed to identify and trace the boundaries of sites of great natural interest, with special reference to areas recognized as such by law (Regional Law 31/89 on parks and nature reserves pursuant to Directive 92/43/EEC "*Habitat*").

At the same time, by means of bibliographic and iconographic research, using both historical and recent sources and work in the field, a systematic inventory of important cultural assets of historical-archaeological and historical-architectural interest, including those of anthropic and historical-technical interest, was compiled (Figure 1).


**Figure 1**. Geographic identification of the study area
(Source: Authors' elaboration from Sardegna Geoportale, 2013)

The information collected was georeferenced and processed by means of GIS software, after which it was used to draw up a specific thematic map of "*Carignano del Sulcis*" vineyards following classification, assessment and adoption of specific legends. The purpose of the map is for use as an instrument providing an immediate, essential synthesis of the existing natural and cultural heritage extant on the soil of the renowned wine and may represent a valid instrument for fruition and exploitation of the land in an area that still presents evident conditions of economic and social distress.

In this sense, the legends provided with the map, divided according to the type of heritage, highlight the diversity and wealth of natural and cultural sites contained in it.

**Geological features**

From the geological standpoint, the area of the soils on which the vineyards grow is characterized by lithologies dating from the Paleozoic to the recent Quaternary (Assorgia et al., 1992), as shown in the legend of the map of the natural and cultural heritage in the landscape of the Carignano wine district of the Sulcis region (SW Sardinia).

The oldest ones are ascribable to the Cambrian-Ordovician „*pre-discordance*" Sardinian sedimentary succession of southwestern Sardinia, amply described in the literature (Carmignani et al., 2001). Subdivided into classic formational groups from bottom to top, they constitute the Nebida Formation, the Gonnesa Formation, the Campo Pisano Formation and the Cabitza Formation. These formations outcrop essentially in the reliefs surrounding the northern, eastern and southern sectors of the area examined.

The Nebida Formation (Lower Cambrian) is divided into the Matoppa Member and the Punta Manna Member. The Matoppa Member is characterized by metasandstones and metasiltites, with flat parallel laminations alternating with decimetric banks of quartzose metasandstones with rare carbonate levels and discontinuous levels of dark metalimestones with Archaeocyatha (Lower Cambrian). The lithofacies in the Punta Manna Member are distinguished at the base by oolithic and oncolithic limestones with subordinate intercalations of metasandstones and metasiltites.

Ascribable to the Gonnesa Formation (Lower Cambrian) are the striped dolostone member with well-stratified and laminated light grey dolostones, often with stromatolithic laminations and nodules and levels of dark flintstone at the base, the ceroid limestone member, characterized by dolostone and massive dolomitic limestones from yellowish to brown, and the member of ceroid limestones with dolostones and massive, grey to hazel, sometimes blackish and often dolomitized dolomitic limestones.

The Campo Pisano formation (Lower to Middle Cambrian) consists of alternations of metalimestones, pink marly metalimestones, grey metasiltites and grey-pink metalimestones with a nodular structure, sometimes silicified, rich in fossil fragments.

The Cabitza formation (Middle Cambrian - Lower Ordovician) is instead characterized by a rhythmic alternation of metasiltitic and metaclayey centimetric layers, red-violet and green in colour of tidal origin, graded grey-green metasiltitic layers and quartzose-feldspar metasandstones with flat parallel crossed and gibbous laminations.

These are followed above by heterometric, polygenic metaconglomerates and metabreccias alternating with metasiltites and purplish metasandstones (Monte Argentu formation; Middle to Upper Ordovician) which bear witness to the results of an important tectonic phase (the "*Sardinian Phase*") and a long period of continentality.

The calc-alkaline nature of the Sardinian plutonic association of the Upper Carboniferous-Permian is highlighted by an intrusive complex characterized by granitic rocks, prevalently reddish in colour (microsieno granites, leukosienogranites and microgranodiorites), and prevalently quartz hydrothermal seams, which outcrop widely in the southeastern sector of the area examined.

The Mesozoic marine ingressions involved this sector of Sardinia only marginally, with limestone dolomitic sediments of the Middle Triassic-Middle Jurassic, present in the area of Porto Pino, to the southwest of the area studied.

More significant is instead the presence of the paleogene sedimentary succession which deposited in a large gulf, clearly of tectonic setup. It begins with limestones, cemented breccias and rare carbonaceous levels, dolostones with quartzose and limestone clasts and purplish-red silty clays, quartzose-feldspar sandstones with frequent traces of bioturbation and heterometric and polygenic conglomerates which are part of the Cixerri Formation, referring to the Middle Eocene-Oligocene. These lithologies, which often compose the soils of "*Carignano del Sulcis*" vineyards, outcropping diffusely at the base of the ignimbritic plains and generically of the tertiary lava spreads, go to make up the supporting base of the alluvial and detritic-colluvial covers of the Quaternary.

A special mark on the Sulcis landscape is left by the Oligo-Miocene volcanic highlands connected to geodynamic processes that led to the detachment of the Sardinia-Corsica microplate from the European continent. The latter are well represented in this area (Assorgia et al., 1992) by pyroclastic flow deposits in ignimbritic facies, with a composition from hyper-alkaline to comenditic rhyolitic (Monte Sirai group) and by andesites and basaltic andesites in cupoliform masses and massive flows with flow structures (Carbonia group). To this lithostratigraphic ensemble also belong the filonian bodies with an andesitic and basaltic composition oriented approximately in the E-W, NE-SW and N-S directions, well-represented on the map.

To the Pleistocene are ascribable conglomerated and ancient alluvions, terraced with subordinate limes and sands (lithofacies of the Portoscuso subsystem), while to the Holocene are connected alluvial deposits, they too sometimes weakly terraced, eluvio-colluvial deposits, slope and landslide deposits. Anthropic deposits, sometimes potentially questionable, are prevalently represented by mine tailings present around the area of the Rosas mines.

**Geomorphology**

Closed in by the metamorphic and granitic reliefs of the Paleozoic and open to the west towards the Gulf of Palmas, the "*Carignano del Sulcis*" landscape is distinguished on the inside by the characteristic ignimbritic highlands of Monte Narcao, Mont'Essu and Sa Corona Arrubia on the slopes of which can be seen the sequence of the Oligo-Miocene volcanic products represented by the pyroclastic flow deposits in ignimbritic facies and massive flows, quite evident at the summit and tabular fills delimited by steep rocky scarps (Figure 2). Correlated to the same volcanic events are the cupoliform masses consisting of andesites and basaltic andesites, with evident flow structures that make up the reliefs of Monte Pisanu, Serra sa Perda and Serra de Mesu to the north of the Monte Pranu reservoir.

As concerns the Monte Essu plateaux and the many other sites of archaeological and geomorphological interest and the forms connected to ground water, the hydrographic network is dominated by three fluvial courses characterized by a fairly sinuous and meandering course in correspondence to the plain and by fairly deep incisions, with a rich array of minor branches of varying orders having a dendritic pattern, within the granitic and metamorphic reliefs. The Riu Mannu of Narcao, coming from the reliefs of the northeast sector starting from Monte Orri (723 m), which empties into the Monte Pranu reservoir, is considered the basic tributary of Rio Palmas, which collects the waters that flow out of the Monte Pranu reservoir at Tratalias and discharges them into the gulf of the same name on the southwestern coast of the island.

Its main affluent, Riu Mannu of Santadi, from the confluence to its point of origin at Monti Mannu (726 m), flows practically southward for about 16 km, with an interesting and lush valley floor which still requires proper works to control it. More to the west of the previous ones is Riu Gutturu Ponti which, starting from the reliefs to the north of Terraseo, flows for some 14 km before discharging into the Monte Pranu reservoir.

This reservoir, which has a net capacity of approximately 50 million cubic meters of water for industry, irrigation and drinking, was built between 1948 and 1951 along Rio Palmas. In 1989, thanks to the excellent characteristics of its shore, it was declared a nature reserve pursuant to Regional Law 31/1989. Another important infrastructure of the same kind for the supplying of water has been added.

It is of smaller capacity (about 8.5 million m³) and is formed by the Bau Pressiu dam set in the alternation of grey-green metasandstones and metasiltites of the Paleozoic schist basement, in a beautiful scenic context determined by the morphological contrast between the granitic landscape and the landscape modelled in schistose-metamorphic rocks.

In correspondence to the prevalently gravelly and sandy Pleistocene alluvial deposits, there are evident terraced forms of fluvial origin characterized by weakly inclined surfaces delimited by scarps which are the expression of more or less prolonged episodes of erosion by the same water courses, caused by eustatic variations, as at Crabi, Punta Serra Manna and Tattinu where in particular the fluvial incisions are impressed on previous alluvial conoids.

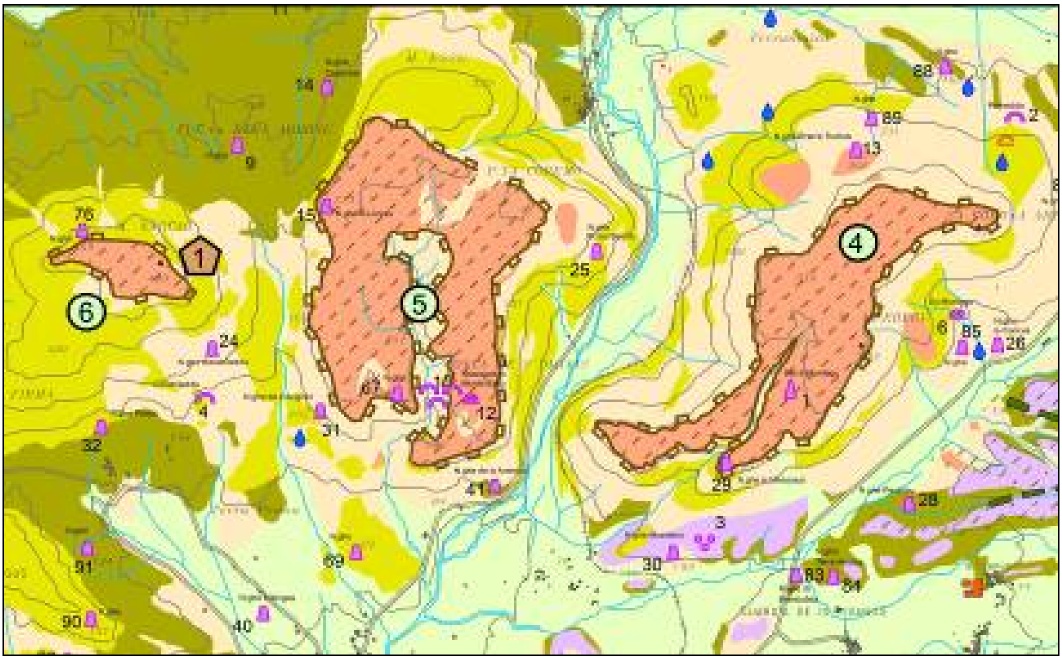


**Figure 2**. The ignimbritic plateaux of Monte Narcao (circle 6), Mont'Essu (circle 5) and Sa Corona Arrubia (circle 4). The volcanic sequence of monte Norcao (pentagon1), The pentagon shape identifies geosites, the circles identify geomorphosites and the relative number identifies each object, while the colour specifies the genetic process (Source: Map of the natural and cultural heritage in the wine of landscape "*Carignano del sulcis*" Di Gregorio F., Frongia P., Piras G., 2013)

The reliefs composed of massive limestone and stratified Cambrian dolostones bear witness to peculiar evolutionary processes of karstic hypogean and epigean nature, such as the splendid underground concretizations of the caves of Is Zuddas and Su Benatzu created by the incessant action of water, located to the south of the town of Santadi. The reliefs of Punta Portellitus and Monte Tamara to the southeast of Nuxis, but also those of Tattinu, are particularly rich in underground karstic environments and surface forms connected with the dissolving of the rock by acid water, in particular furrowed fields (Barca & Gregorio, 1999). The Bacchera and Cava Romana caves to the south of Nuxis are worthy of mention. The slopes of Monte S'Orcu, to the north of Perdaxius, those of Monte Ega and Punta Pitturra to the north of Narcao, as well as between Punta Masonis and Guardia Manna to the north of Rio Murtas, a suburb of Narcao, present interesting karstic forms underground and evident epigean structures connected with processes of dissolution of carbonatic rocks, among which are also small dolines.

In this landscape characterized by a great lithologic, chronostratigraphic and geomorphological diversity, a systematic survey identified and classified in terms of genetics numerous geological and geomorphological sites of special educational scientific and cultural touristic interest, such as „*Sa Fraigada*" (Figure 3). After proper georeferencing they were included in a database and reported on the map of natural and cultural sites of the „*Carignano del Sulcis*" landscape. These elements were more properly distinguished as geological sites when they have considerable importance in the reading and interpretation of geological features of an area, such as Monte Narcao and Monte Sa Turri formations and volcanic structures and geomorphosites, where they represent a unique genetic model and geomorphological evolution.

**Figure 3**. The Sa Fraigada geomorphosite is a large *tafone* formed by meteoric erosion of a *tor* modeled in Sulcis pink granites (Source: Di Gregorio F.)

**Other features of the natural and cultural heritage**

Besides the geographical and physical heritage ascribable to the lithological and morphological diversity described above, the land under examination also features quite interesting archaeological, historic and architectural sites, not to mention those of industrial archaeology owing to the presence of mines and mining settlements, some of which have been well restored for use in the fields of tourism and cultural initiatives, thanks also to their being part of the Geomining, Historical and Environmental Park of Sardinia which has been included among the UNESCO sites. In the last century, the region was involved in the exploitation of many important mines with stratiform and/or paleokarstic ore deposits, prevalently of Pb, Zn and Ba and with hydrothermal and/or thermal-metamorphic annexes. Together with the important changes of the land and issues connected with water and soil pollution, these activities have also produced interesting and varied mining landscapes, with extraordinary examples of industrial archaeology such as the Rosas washery and mining town, Mont'Ega and the Sa Marchesa mines.

Together with mining resources, the mountains have contributed to the setting up of activities connected with woodland exploitation. The old abandoned Pantaleo-Santadi-Portobotte railway, built at the beginning of the 20th century by the Compagnie des Hauts Fourneaux, was not only for transporting ore from the San Leone mine, but also for that of charcoal produced in the Pantaleo woodland. Of the industrial railway, which was active up to 1957, as well as some fine buildings restored in the area of Pantaleo's woodland, now state-owned, some parts used for ore transportation to Porto Botte in the Gulf of Palmas are now used as part of the local road network.

There also remains the winding narrow-gauge Siliqua-Calasetta passenger railway between the castle of Siliqua and Terrubia, which was active from 1926 to 1968 and the flat part of which is now in use as part of the rural road network. Also extant are interesting and admirable engineering works, such as daring arched bridges, level-crossings and local stations.

Connected with the mutually profitable relationship between humans and the land and its resources are the traditional historic settlements of Medau and Furriodroxiu, the aggregations of houses and stalls used in the process of colonization of the land by farmers and livestock breeders all over the Sulcis region.

Among the exceptional historic and architectural assets are churches of great historic value such as Sant'Elia of Nuxis near the nuragic sacred well at Tattinu and Santa Maria di Monserrato at Tratalias.

The Sulcis region is also characterized by a vast mountainous area of natural and vegetational interest in the eastern sector, which is included in the Sulcis regional park and protected under the provisions of Regional Law 31/1989; the same law protects the nature reserve of the Monte Pranu reservoir, around which several geosites generically referable to tertiary volcanism were identified in the course of this study.

## THE GEOARCHAEOLOGICAL HERITAGE

Within the context of this rich and varied landscape there is also an geoarchaeological patrimony of extraordinary interest thanks to its density and chronological diversity. The most important of these are described below.

### The megalithic monuments: The Giants' Tomb of Sa Fraigada

At the foot of the Monte Nieddu (1041 m a.s.l.) granite complex, along the steep banks of the Baccu Mannu stream in a scenic context of great beauty, rise the peaks of Sa Punta de su Casteddu, so-called because they resemble the walls of a castle. During the Middle Bronze Age, around 1300 B.C. (Atzeni, 1972; Moravetti, 1985), at this site, which forms a natural outcrop, nuragic peoples erected an extraordinary megalithic monument, a *Tomba di Giganti* (giants' grave) (Figure 4), the popular name for a monumental collective grave. Set at the top of the relief, beside a tunnel created by weathering (*fraigada*, Sardinian for eroded), this structure is composed of a vestibule made of two courses of cyclopean granite blocks arranged in a semicircle; at the center is a rectangular entrance oriented southwards surmounted by a huge architrave with a pediment of sub-rectangular blocks rising to a height of about 4 meters.

The interior is a long corridor used as the burial chamber, with overhanging walls covered with large stone slabs. The grave, with an overall length of 14 meters, is closed to the north by an apse. The floor plan and cross-section propose a stylized taurine protome and the appearance of an upside-down boat. In connection with the grave, along the gully providing access to the tomb there are traces of a village with round huts built of dry walls which were probably covered with leafy branches. Today they are immersed in the lush vegetation. In defence of the settlement and the entire funerary structure are imposing walls reaching 1.5 m in thickness which obstructed all possibilities of access to the rugged needles of the steep slopes.

The Nuraghe Mannu, located at no more than 500 m to the north, built making use of a rocky outcrop, was the residence of the people who administered the economic resources of that land, characterized mostly by the presence of iron ore from the nearby Bacchisceddu mine, the fertile soils in the valley and the lush pastures on the surrounding slopes. The Sa Fraigada settlement was the logical outpost.

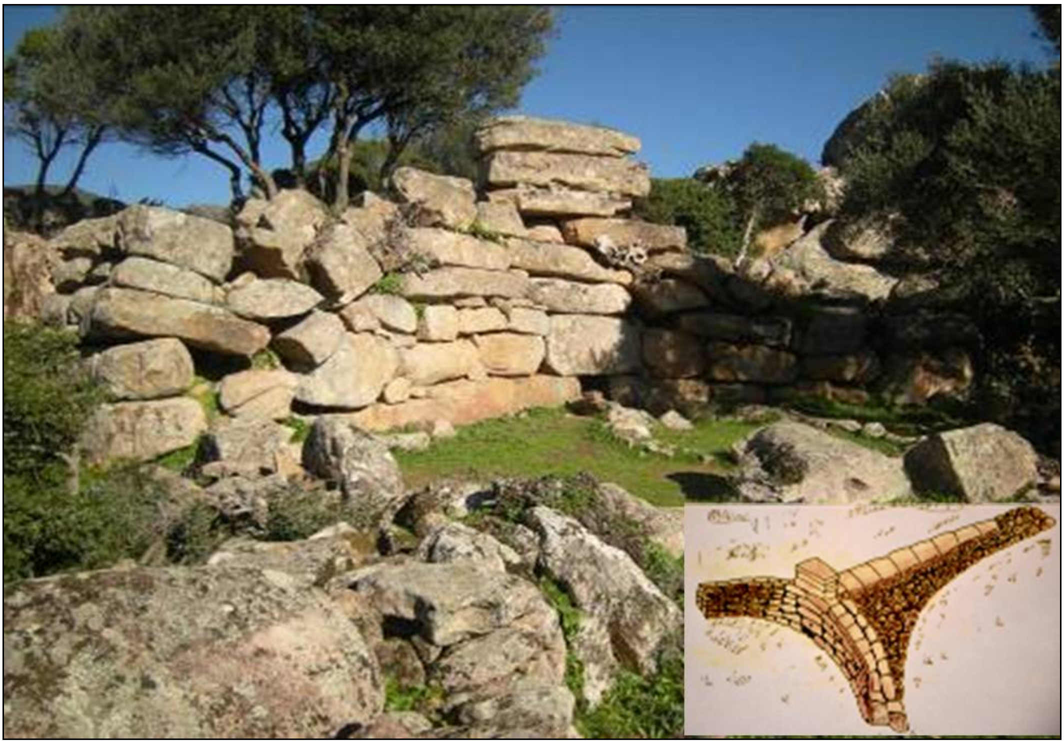

**Figure 4**. The Giants' Tomb of "*Sa Fraigada*" and a 3D model (Source: Piras G.)

**The prehistoric necropolis with rupestrian graves at Montessu (Villaperuccio)**

The Montessu necropolis covers an extensive natural amphitheatre at a place known as Su Crabì di Montessu, located on the southern slopes of the Sa Pranedda plateau (216 m), 2 km to the northwest of Villaperuccio. The graves were dug with picks into a consistent wall of relatively soft and compact tufaceous volcanic rock by peoples of probable middle eastern origin which have been assigned to contexts of the Ozieri culture (3500-2800 B.C.). The hypogea fit into the Sardinian *domus de janas* typology of prenuragic age: they are classified on the basis of their floor plans and have one or more cells (Atzeni, 1972). The three-grave sanctuaries are extraordinary, with monumental entrances behind ample megalithic enclosures and large chambers for religious ceremonies.

On the walls of some of the graves are decorative and symbolic motifs connected with the veneration of the dead: silhouettes of mother goddesses, taurine protomes symbolizing fertility and rebirth (Lilliu, 1987), often decorated with red bands representing blood, the source of life for these ancient peoples. These are all testimonials of faith, undeniable signs of heartfelt religiousness expressed simply yet rich in spirituality as well as an expression of artistic skill.

**The hypogean temple of Su Benatzu (Santadi)**

From the archaeological standpoint, the discovery of the Su Benatzu karstic cave in 1968 was the most extraordinary one of the last century in Sardinia (Todde, 1972). Situated near the hamlet of Su Benatzu in the municipality of Santadi, the vast karstic cave presents a room used in nuragic times as a temple dedicated to water divinities (Maxia, 1972), and reveals an aspect of the naturalistic religion connected to a chthonian cult of the divinities of the nether world. On the back wall is a stalagmite, probably purposely broken, which served as an altar on which were placed bronze objects: a sacrificial knife and a votive boat. Beside it, distinct and precious, was a small ornamental tripod of skilful making, with geometric designs in relief, bull heads and spherical pendants of the Cypriot-Mycenaean tradition. Half hidden by the ashes in the hearth numerous terracotta pots, more than two thousand in all were deposited in three heaps (Sedda, 1971), they are now in Santadi's archaeological museum. The votive hoard consisted of 109 metal objects of copper, bronze and gold which included daggers, swords, spearheads, bracelets and pins. The gold objects were a crested ring and a rectangular blade.

**The Sacred Well of Tattinu (Nuxis)**

It has now been acknowledged by all scholars that the highest architectural expression of nuragic peoples was reached in the construction of sacred wells, ceremonial places dedicated to the water divinities (Lilliu, 1972).

In the 13th century B.C., on the southwestern slopes of Monte Nieddu in the territory of Nuxis, nuragic peoples built a well temple to gratify the religious beliefs of the communities in the area, where probably disputes between tribes and families were settled, political alliances were negotiated and the defence of the area against dangers from the outside was planned (Atzeni, 1987). The sacred area consisted of a vestibule where purification rites were performed and offerings were made before descending a stairway of 18 stone steps of irregular shape to the water basin. An underground stone tholos or beehive structure protected the spring. The surrounding area features the remains of circular huts which were probably built as shelters for pilgrims coming from settlements in the area. One fairly large one in particular, perhaps the assembly hut, was probably used by tribal chiefs and priests to discuss economic matters, social relations and perhaps tribal alliances.

**Nuragic settlements**

Archaeological research has established that the height of human domination of the lands in the Lower Sulcis was reached sometime around the 15th century B.C. (Pracchi, 1963). This is proved by the numerous characteristic megalithic tholos towers strongly concentrated in hilly areas and on slopes in defence of the fertile lands in the valleys.

Placed at the top of hills, in sight of one another so as to delimit specific lands, more than ninety nuraghes, villages and megalithic circles indicate the socio-economic importance of the area and the functions it was to perform. Thus we have the Murrecci quadrilobate complex controlling the Su Benatzu valley and especially the hypogean temple of the now famous Su Benatzu or Pirosu cave, where the extraordinary archaeological findings described above were brought to light.

The same can be said for the Sanna and Is Collus nuraghes which dominated the fluvial valleys of Rio Mannu and the Pani Loriga hill. The Muentinu and Serr'e Murdegu nuraghes on the ignimbritic tablelands of Pranedda overlooked Nuxis. The Sessini and Munserrau nuraghes defended accesses to the fertile Villaperuccio valley.

However, these imposing towers are not to be considered merely as watchtowers: they were part of a system connecting them closely together to delimit lands, thus indicating communities which used the habitat for the purpose of collectively managing their economic assets and equitably distributing the resources from farming, animal husbandry and mining. All this explains the choice of settling on the high ground, the low hills or foothills, always in connection with the run-off of water to ensure its use for farming and livestock breeding. This multiplicity of functions also explains the lack of nuragic settlements in impervious mountainous areas unsuitable for agriculture.

**The Pani Loriga Phoenician-Punic fortress (Santadi)**

The Pani Loriga archaeological site is quite important in the study of the Phoenician-Punic colonization of the Sulcis region. Founded in the 7th century BC by Phoenician colonists who had previously settled along the entire southwestern coast of Sardinia, the settlement survived for a long period, as can be seen from evidence brought to light during excavations (Barreca, 1983; Moscati, 1979). The village rises on a hill no more than 200 meters in height. A ravine, the sides of which are in some places quite steep, divides the plain. The relief, magmatic in origin, rises isolated in the middle of the Santadi plain along the Rio Mannu basin, at the crossroads of two important commercial routes. The first, following the bed of the Rio Mannu of Narcao, made it possible to reach the Campanasissa pass and from there the large geographic region known as the Campidano of Cagliari. The second is that of the Rio Mannu of Santadi, whose valley places in communication the Sulcis region with the wetlands and Gulf of Cagliari.

The importance of the site is immediately apparent: it rises as a defensive bastion, but its economic function is also important in that it gave control over the vast Sulcis coastal plain as well as providing important agricultural produce and the possibility of controlling and exploiting the ores of which the surrounding land is rich. Besides the settlement, only partially excavated, there are two other areas for the necropolises; one with graves for the cremated and the other for chamber graves in which were found precious and elegant votive offerings. From the study of these, a Phoenician presence in the 7th century BC (Moscati, 1979) for Pani Loriga has been established, while a Phoenician presence is certain starting from the 5th century BC (Barreca, 1983).

**The Byzantine church of Sant'Elia (Nuxis)**

Below the slopes of Monte Nieddu, the Tattinu valley has always played an important role in human occupation of the land. Already in prehistoric times people exploited the main karstic caves, as can be seen from the settlements dating back to the 6th millennium BC.

During the age of the nuraghes, the sacred well at Tattinu, an early pagan religious monument, was erected for veneration of water. Later, some time around 1000 BC, in the historic period, the Byzantines built a rural Christian sanctuary dedicated to Sant' Elia at a short distance from the pagan temple. Small in size, typical of small rural churches, its floor plan is that of the Greek cross with four arms: a pseudo tambour covered by a conical cupola is placed where they cross. The roof of the arms is double pitched.

The walls are characterized by the irregularity of the ashlars; the quoins are well laid and intagliated. A cornice of projecting eaves placed under the pitches of the roof follow the entire perimeter of the building and are the only decoration of the monument. The plain main entrance is in the western façade and surmounted by an arched bell gable. The interior is simple and austere, with a modest altar situated at the end of the eastern arm.

**The Archaeological Museum of Santadi**

Situated in the old town centre, at the foot of the park on the hill of San Nicolò, this modern museum houses the findings from excavations and archaeological studies performed in the Lower Sulcis region as well as from the numerous archaeological sites of which the land has a wealth. The findings placed chronologically trace a vast cultural panorama starting from the 6th millennium BC up to the final stages of Roman civilization in the 4th century AD. The Neolithic is represented by findings relating to the first human settlements in the karstic caves of Perda Tuvura, Cirixì and Tattinu eight thousand years ago.

These were followed by the creation of villages composed of huts in the open, the birth of agriculture and animal husbandry. Millstones, pestles, axes, arrow- and spearheads, knives, obsidian scrapers, whorls and pottery impressed with matting reveal the activities of everyday life. The later ages of the metals are represented by plaques, axes, copper daggers and an interesting silver bead from a necklace. Lead is represented by clamps still attached to pottery showing that repairs were already in use. A vast exhibition of pottery from the Early Bronze Age comes from excavations and research in the Montessu necropolis, associated with fine copper daggers and vitreous paste necklace beads.

But the most noteworthy aspect of the museum's treasures is the display of thousands of pots, daggers and bronze votive tripods of Cypriot inspiration found in the hypogean temple in the Su Benatzu cave. The Semitic world is represented by grave goods from the cemetery of the cremated in the Phoenician-Punic settlement of Pani Loriga.

The exhibition closes with a cross-section of Roman civilization, both republican and imperial, with grave goods, cinerary urns, wine amphoras and a limestone bust probably representing the god Bacchus. The restoration laboratory contains a large amount of material which will become the nucleus of the museum when the planned exhibition takes place.

**CONCLUSIONS**

The natural and cultural assets are synthesized in the Map of the natural and cultural heritage in the landscape where „*Carignano del Sulcis*” wine is produced (SW Sardinia)(Figure 5). The information collected through bibliographic analyses, interpretation of aerial photographs and field surveys is presented on the map which was created on a GIS support so as to correctly georeference the several elements.

The map represents a fundamental and direct instrument for locating the territory's heritage and will be especially useful in formulating ideas and drawing up plans for fruition and sustainable exploitation of the environment.

In this sense, the legends provided with the map, subdivided by the type of heritage, highlight the diversity and wealth of natural and cultural assets contained in it. In particular, the research performed has brought to the fore that in the area studied there are numerous geosites and geomorphosites, the latter the result of different genetic processes: weathering (tafoni and tors), karstic (caves with relative concretions), volcanic and structural (tabular ignimbritic plateaux) and so on.

# CARTA DEI BENI NATURALI E CULTURALI NEL PAESAGGIO DEL CARIGNANO DEL SULCIS (SARDEGNA SW)

## *MAP OF THE NATURAL AND CULTURAL HERITAGE IN THE WINE LANDSCAPE "CARIGNANO DEL SULCIS" (SARDEGNA SW)*


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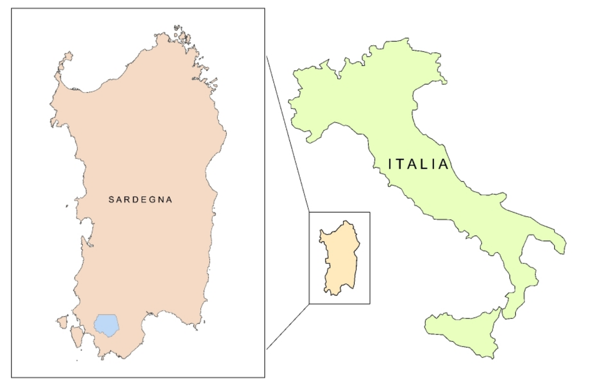
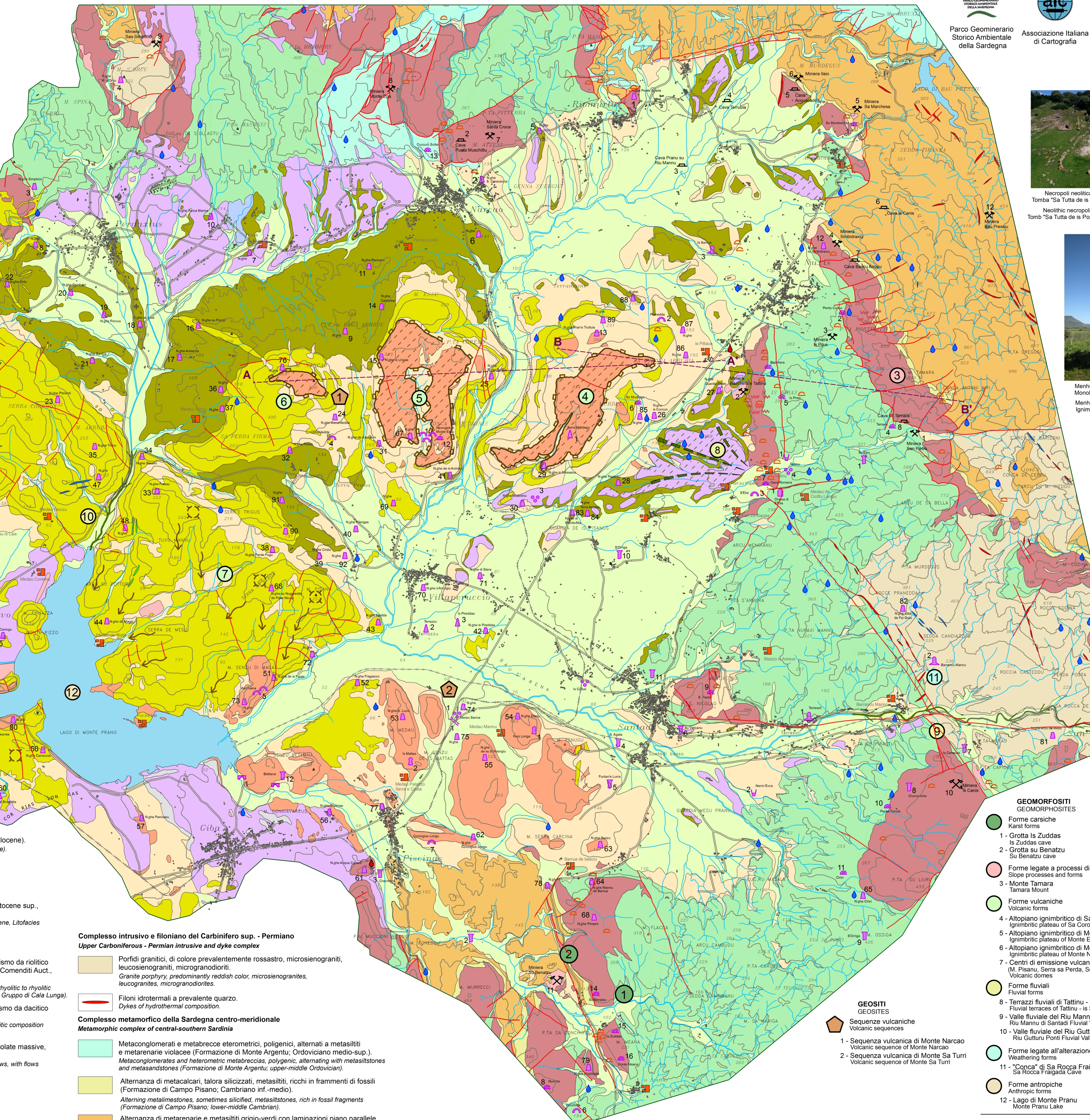
Parco Geominerario Storico Ambientale della Sardegna · Associazione Italiana di Cartografia · Università di Cagliari Dipartimento di Scienze Chimiche e Geologiche · Cantina Sociale SANTADI




Necropoli neolitica di Montessu (Villaperuccio)
Tomba "Sa Tutta de is Porcus" con relativo recinto sacro

Neolithic necropolis of Montessu (Villaperuccio)
Tomb "Sa Tutta de is Porcus" with relative sacred enclosure

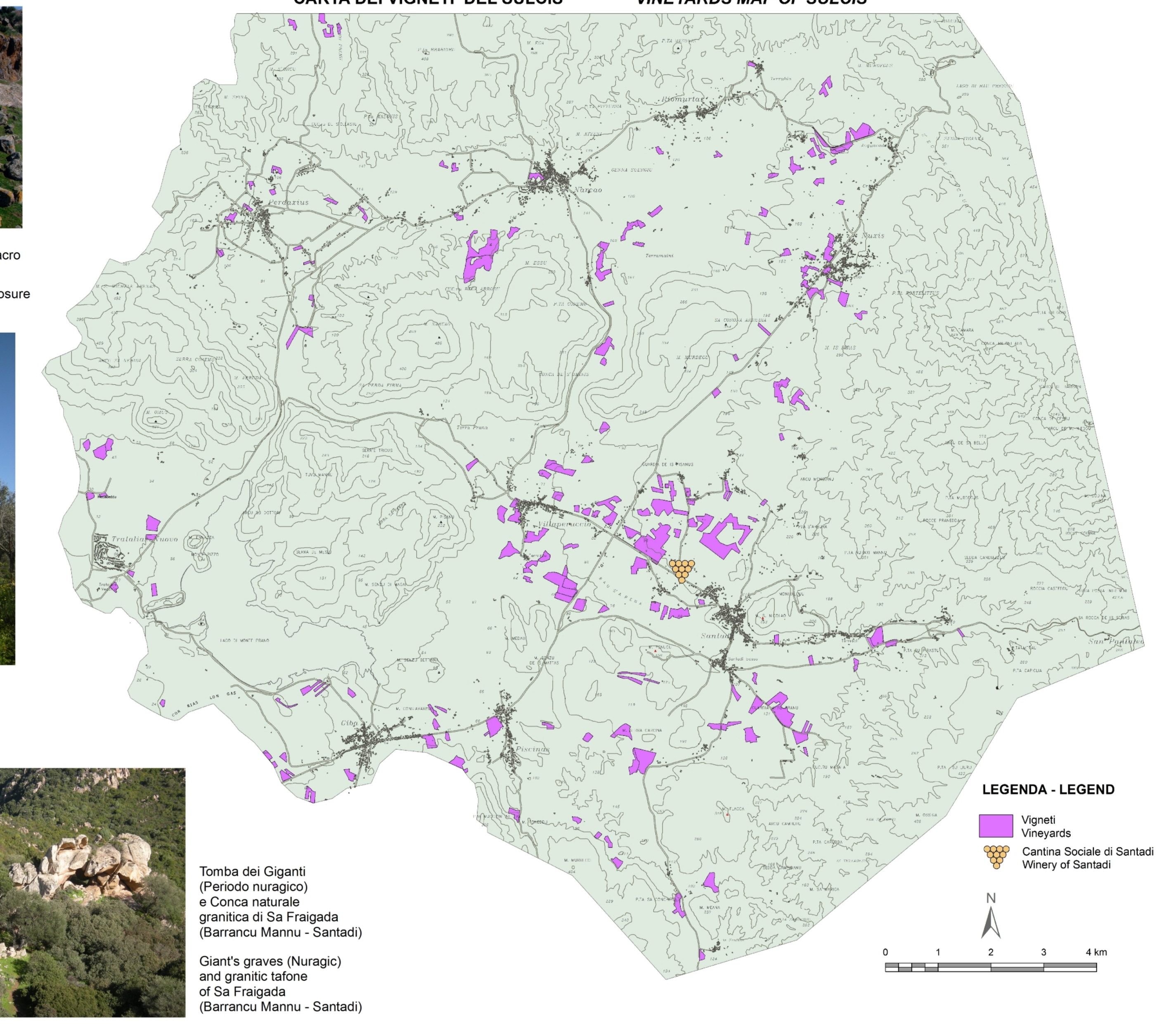
Menhir di Terrazzu (Villaperuccio).
Monolite ignimbritico alto oltre 5m.

Menhir of Terrazzu (Villaperuccio).
Ignimbritic monolith over 5m high.

Tomba dei Giganti (Periodo nuragico) e Conca naturale granitica di Sa Fraigada (Barrancu Mannu - Santadi)

Giant's graves (Nuragic) and granitic tafone of Sa Fraigada (Barrancu Mannu - Santadi)

### CARTA DEI VIGNETI DEL SULCIS — *VINEYARDS MAP OF SULCIS*




## Legenda Geologica
## *Geologic Legend*

**Depositi continentali del Quaternario**
***Quaternary continental deposits***

- Depositi antropici: discariche minerarie e materiali di riporto (Olocene). *Anthropic deposits: mining wastes and landfills (Holocene).*
- Depositi eluvio-colluviali. Depositi di versante e di frana (Olocene). *Eluvial-colluvial deposits. Landslide and slope deposits (Holocene).*
- Depositi alluvionali, talora terrazzati (Olocene). *Alluvial deposits, sometimes in fluvial terraces (Holocene).*

**Depositi continentali del Pleistocene**
***Pleistocene continental deposits***

- Ghiaie alluvionali terrazzate con subordinate sabbie (Pleistocene sup., Litofacies del Subsintema di Portoscuso). *Terraced alluvial gravels with subordinate sands (Upper Pleistocene, Litofacies del Subsintema di Portoscuso).*

**Complesso vulcanico Oligo-miocenico del Sulcis**
***Oligo-Miocene volcanic complex of Sulcis area***

- Depositi di flusso piroclastico in facies ignimbritica, a chimismo da riolitico iperalcalino a riolitico comenditico (Rioliti di Monte Ulmus; Comenditi Auct., Gruppo di Cala Lunga). *Pyroclastic flow deposits in ignimbritic facies from hyperalkaline rhyolitic to rhyolitic comenditic composition (Rioliti di Monte Ulmus; Comenditi Auct.; Gruppo di Cala Lunga).*
- Depositi di flusso piroclastico in facies ignimbritica a chimismo da dacitico a riolitico (Gruppo di Monte Sirai). *Pyroclastic flow deposits in ignimbritic facies from dacitic to rhyolitic composition (Gruppo di Monte Sirai).*
- Andesiti ed andesiti basaltiche in ammassi cupoliformi e colate massive, con strutture di flusso (Gruppo di Carbonia). *Andesites and basaltic andesites as lava domes and massive flows, with flows structures (Gruppo di Carbonia).*
- Filoni a composizione intermedia. *Dykes of intermediate composition.*
- Filoni a composizione basica. *Dykes of basaltic composition.*

**Successione sedimentaria paleogenica della Sardegna sud-occidentale**
***Paleogenic sedimentary succession of the south-western Sardinia***

- Argille siltose, arenarie quarzoso-feldspatiche con frequenti tracce di bioturbazione, conglomerati eterometrici e poligenici debolmente cementati ("Formazione del Cixerri"; Eocene med.-?Oligocene). *Silty clays, quartz-feldspathic rich sandstones with frequent traces of bioturbation, heterometric and polygenic conglomerates weakly cemented ("Formazione del Cixerri"; lower Eocene-?Oligocene).*
- Calcari, brecce cementate e rari livelli carboniosi. Dolomie con clasti quarzosi e calcari ("Lignitifero" Auct.; Eocene inf.-medio). *Limestones, cemented breccias and rare coal levels. Dolostones with quartz clasts ("Lignitifero" Auct.; lower-middle Eocene).*

**Complesso intrusivo e filoniano del Carbinifero sup. - Permiano**
***Upper Carboniferous - Permian intrusive and dyke complex***

- Porfidi granitici, di colore prevalentemente rossastro, microsienograniti, leucosienograniti, microgranodioriti. *Granite porphyry, predominantly reddish color, microsienogranites, leucogranites, microgranodiorites.*
- Filoni idrotermali a prevalente quarzo. *Dykes of hydrothermal composition.*

**Complesso metamorfico della Sardegna centro-meridionale**
***Metamorphic complex of central-southern Sardinia***

- Metaconglomerati e metabrecce eterometrici, poligenici, alternati a metasiltiti e metarenarie violacee (Formazione di Monte Argentu; Ordoviciano medio-sup.). *Metaconglomerates and heterometric metabreccias, polygenic, alternating with metasiltstones and metasandstones (Formazione di Monte Argentu; upper-middle Ordovician).*
- Alternanza di metacalcari, talora silicizzati, metasiltiti, ricchi in frammenti di fossili (Formazione di Campo Pisano; Cambriano inf.-medio). *Alterning metalimestones, sometimes silicified, metasiltstones, rich in fossil fragments (Formazione di Campo Pisano; lower-middle Cambrian).*
- Alternanza di metarenarie e metasiltiti grigio-verdi con laminazioni piano parallele ed incrociate (Formazione di Cabitza; Cambriano med. - Ordoviciano inf.). *Alternating metasandstones and gray-green metasiltstones with plane-parallel and cross laminations (Formazione di Cabitza; middle Cambrian - lover Ordovician).*
- Calcari grigi massivi, talora nerastri. Dolomie grigie stratificate e laminate (Formazione di Gonnesa; Cambriano inf.). *Massive gray limestones, sometimes blackish. Stratified and laminated gray dolostones (Formazione di Gonnesa, lower Cambrian).*
- Metarenarie e metasiltiti, con laminazioni piano-parallele, alternate a metarenarie quarzose, con rari livelli carbonatici. Alla base calcari oolitici e oncolitici (Formazione di Nebida; Cambriano inf.). *Metasandstones and metasiltstones with plane-parallel laminations, alternating quartzitic metasandstones, with rare carbonatic levels. Oolitic limestones and oncolytics at the bottom ("Formazione di Nebida", Lower Cambrian).*

Per le caratteristiche geologiche e litostratigrafiche si è fatto riferimento ai seguenti lavori:


APAT - Dipartimento Difesa del Suolo-Servizio Geologico d'Italia, Carta Geologica d'Italia alla scala 1:50.000, Foglio 564 "Carbonia" (2012); Foglio 565 "Capoterra" (2009).
Assorgia A., Brotzu P., Callegari E., Fadda A., Lonis R., Ottelli L., Ruffini R., Abrate T. (1992), Carta geologica del distretto vulcanico cenozoico del Sulcis (Sardegna sud-occidentale). Scala 1:50.000, S.EL.CA.
Barca S., Di Gregorio F. (1999), Paesaggi e Monumenti geologici della Provincia di Cagliari, Saredit srl, Cagliari.


### GEOSITI
GEOSITES

Sequenze vulcaniche
Volcanic sequences

1 - Sequenza vulcanica di Monte Narcao
Volcanic sequence of Monte Narcao
2 - Sequenza vulcanica di Monte Sa Turri
Volcanic sequence of Monte Sa Turri

### GEOMORFOSITI
GEOMORPHOSITES

Forme carsiche
Karst forms
1 - Grotta Is Zuddas
Is Zuddas cave
2 - Grotta su Benatzu
Su Benatzu cave

Forme legate a processi di versante
Slope processes and forms
3 - Monte Tamara
Tamara Mount

Forme vulcaniche
Volcanic forms
4 - Altopiano ignimbritico di Sa Corona Arrubia
Ignimbritic plateau of Sa Corona Arrubia
5 - Altopiano ignimbritico di Monte Essu
Ignimbritic plateau of Monte Essu
6 - Altopiano ignimbritico di Monte Narcao
Ignimbritic plateau of Monte Narcao
7 - Centri di emissione vulcanica
(M. Pisanu, Serra sa Perda, Serra de Mesu)
Volcanic domes

Forme fluviali
Fluvial forms
8 - Terrazzi fluviali di Tattinu - is Scanus
Fluvial terraces of Tattinu - is Scanus
9 - Valle fluviale del Riu Mannu di Santadi
Riu Mannu di Santadi Fluvial Valley
10 - Valle fluviale del Riu Gutturu Ponti
Riu Gutturu Ponti Fluvial Valley

Forme legate all'alterazione meteorica
Weathering forms
11 - "Conca" di Sa Rocca Fraigada
Sa Rocca Fraigada Cave

Forme antropiche
Anthropic forms
12 - Lago di Monte Pranu
Monte Pranu Lake

### SITI DI INTERESSE GEOLOGICO-GEOMORFOLOGICO
SITES OF GEOLOGICAL-GEOMORPHOLOGICAL INTEREST

Elementi strutturali
Structural elements
- Faglie e fratture / Faults and fractures

Idrologia
Hydrology
- Corsi d'acqua / River
- Sorgenti / Source
- Sorgenti termali / Hot source

Forme fluviali e di versante dovute al dilavamento
Fluvial and slope forms
- Gole e canaloni fluviali / Gorges and fluvial channel
- Terrazzi fluviali / Fluvial terrace
- Conoidi alluvionali inattivi / Inactive alluvial fans

Forme strutturali e vulcaniche
Structural and volcanic forms
- Orli di scarpate rocciose / Edge
- Altopiani ignimbritici / Ignimbritic plateau
  1 - M. Narcao
  2 - M. Essu
  3 - Sa Corona Arrubia
- Cupole laviche / Lava domes
- Colate con evidenti direzioni di flusso / Volcanic flows

Forme carsiche
Karstic forms
- Grotte / Caves
- Area a campi solcati / Karren field
- Doline / Doline

### SITI DI INTERESSE STORICO-TECNOLOGICO
SITES OF HISTORICAL AND TECHNOLOGICAL INTEREST

Dighe e bacini
Dams and reservoirs

Cave abbandonate
Abandoned quarries
1 - Nuraghe Senzu - Vulcaniti (Tratalias)
2 - Punta Muschittu - Marmo (Narcao)
3 - Pranu su Riu Mannu - Alluvioni (Narcao)
4 - Terrubia - Alluvioni (Narcao)
5 - Acquacadda - Calcare (Nuxis)
6 - Is Canis-Crabi - Calcare (Nuxis)
7 - Baccu Arrosu - Calcare (Nuxis)
8 - Cava M. Tamara - Marmo nero (Nuxis)

Miniere abbandonate
Abandoned mines
1 - S. Pietro - Nuxis (Pb-Zn)
2 - Bacchera e Tattinu - Nuxis (Ba)
3 - Is Pilus - Nuxis (Pb)
4 - Su Sinibidraxiu - Nuxis (Pb-Zn-Cu)
5 - Sa Marchesa - Nuxis (Pb-Zn-Cu)
6 - Ilaio - Nuxis (Pb)
7 - S. Croce - Narcao (Pb-Zn)
8 - M. Ega - Narcao (Ba)
9 - S. Simplicio - Perdaxius (Pb-Zn)
10 - Is Canis - Santadi (F)
11 - Su Benatzu - Santadi (Ba)
12 - Bau Pressiu - Nuxis (Ba)

Insediamenti storico-tradizionali
Historical-Traditional settlements

Ferrovie storiche dismesse
Historical railway abandoned
- Ferrovie ex-Meridionali della Sardegna Linea Siliqua-Calasetta (1926-68)
- Ferrovia industriale Pantaleo-Porto Botte (1914-57)

Chiese di interesse storico-architettonico
Architectural and historical interest Church
1 - Chiesa di S. Elia (Nuxis)
2 - Chiesa di S. Maria di Monserrato (Tratalias)

(*) Nuraghi
(*) Nuraghes

1 - Perda Spada; 2 - S. Crescenzia; 3 - Simplicio; 4 - Monte s'Orcu; 5 - Nuraghe; 6 - Nuraghe; 7 - Nuraghe; 8 - Nuraghe; 9 - Nuraghe; 10 - Tanca Manna; 11 - Panicani; 12 - Su Sinibidraxiu; 13 - Pran'e Trutturis; 14 - Calabresi; 15 - Is Linzas; 16 - Su Porcili; 17 - Achenza; 18 - Sa Idda; 19 - Porcus; 20 - Camboni; 21 - Santus; 22 - Entu; 23 - Pitzienti; 24 - Conchiledda; 25 - Scrau Becciu; 26 - Is Cuccus; 27 - Guardia Cristo; 28 - Perdosu; 29 - Is Messaius; 30 - Muentinu; 31 - De s'Angioni; 32 - Pimtus; 33 - Frassu; 34 - Sessini; 35 - Tronu; 36 - Nuraghe; 37 - Nuraghe; 38 - Perd'e Fogu; 39 - Cristu; 40 - Manigas; 41 - De is Animas; 42 - Is Pireddas; 43 - Niedda; 44 - De Magai; 45 - De Carrogu; 46 - Tratalias; 47 - Nuraghe; 48 - Nuraghe; 49 - Senis; 50 - Meurras; 51 - De is Paras; 52 - Fragiacco; 53 - S. Lucia; 54 - Diana; 55 - De su Schisorgiu; 56 - Is Ulmas; 57 - Panicasu; 58 - Carroccia; 59 - Rubiu; 60 - Brugnitta; 61 - Acqua Callenti; 62 - Corongius Longus; 63 - Senzu; 64 - Mannu de Barrua; 65 - Cirixi; 66 - Piras Nicola; 67 - Nuraghe; 68 - Pimpini; 69 - Nuraghe; 70 - s'Arragiu; 71 - Stera; 72 - Nuraghe; 73 - Nuraghe; 74 - Nuraghe; 75 - Nuraghe; 76 - M. Narcao; 77 - Nuraghe; 78 - Nuraghe; 79 - Monticello; 80 - Nuraghe; 81 - Arcu de Mesu; 82 - Tutta de Fai Grau; 83 - Brenticotta; 84 - Terra Arrubia; 85 - Nuraghe; 86 - Nuraghe; 87 - Nuraghe; 88 - Nuraghe; 89 - Nuraghe; 90 - Nuraghe; 91 - Nuraghe

### SITI DI INTERESSE STORICO-ARCHEOLOGICO
SITES OF HISTORICAL - ARCHAEOLOGICAL INTEREST

**NEOLITICO (NEOLITIC)**

Necropoli a Domus de Janas
Burial niches
1 - Monte Essu (Villaperuccio)
2 - Pranedda (Nuxis)
3 - S. Elia (Nuxis)
4 - Conchileddu (Villaperuccio)
5 - Marchiana (Villaperuccio)
6 - Conchitta (Santadi)
7 - Corongiu Longu (Piscinas)

Menhir
Menhir
1 - Serra Murdegu (Nuxis-Narcao)
2 - Terrazzu (Villaperuccio)
3 - Is Pireddas (Villaperuccio)

Grotta con tracce di insediamento
Caves with traces of settlement
1 - Su Montixeddu (Nuxis)
2 - Perdu Cuccu (Nuxis)
3 - Bacchera (Nuxis)
4 - Tamara (Nuxis)
5 - Is Piras (Nuxis)
6 - Su Murdegu (Nuxis)
7 - Cava Romana (Nuxis)
8 - Nurchis (Santadi)
9 - S. Paolo (Santadi)
10 - Perda Tuvura (Santadi)
11 - Cirixi (Santadi)
12 - Conca de is Ominis (Villaperuccio)
13 - Cuccuru Sollais (Narcao)
14 - Su Benatzu (Santadi)
15 - In Zuddas (Santadi)
16 - Monte Meana (Santadi)

**NURAGICO (NURAGIC)**

Tombe dei giganti
Giant's graves
1 - Terresoli (Santadi)
2 - Barrancu Mannu (Santadi)
3 - Is Santus (Nuxis)

Pozzi sacri
Sacred pits
1 - Tattinu (Nuxis)
2 - Nanni Ecca (Santadi)

Nuraghi (*)
Nuraghes (*)

Villaggio nuragico
Nuragic village
1 - Merau Sanna (Santadi)
2 - Is Collus (Santadi)
3 - N.ghe Muertinu (Villaperuccio)
4 - Tattinu (Nuxis)

**PUNICO (PUNIC)**

Insediamenti punici
Punic's settlements
1 - Fortezza di Pani Loriga (Santadi)
2 - Is Mattas (Piscinas)
3 - Corona Arrubia (Nuxis)

**ROMANO (ROMAN)**

Insediamenti romani
Roman's settlements
1 - Su Tipu (Nuxis)
2 - Murrecci (Santadi)
3 - Cracchera (Piscinas)
4 - S. Agata (Santadi)
5 - Funtan'e Lurra (Santadi)
6 - Su Vaticanu (Santadi)
7 - Is Cerexias (Santadi)
8 - Cruccuronis (Santadi)
9 - S'Ossiga (Santadi)
10 - Is Piroddis (Nuxis)
11 - S'Arririgau (Santadi)
12 - Bettiana

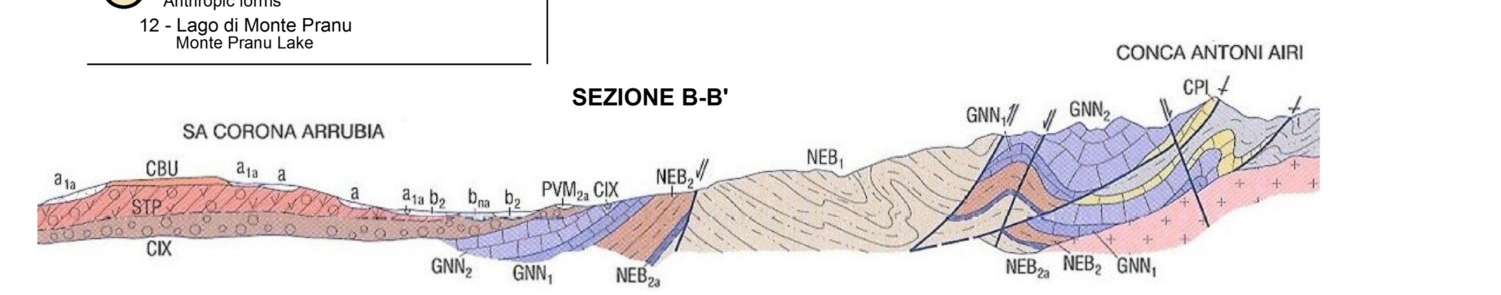
Strade romane
Roman roads
1 - Merau Sanna (Santadi)

Ponti romani
Roman bridges
1 - Riu di Piscinas (Piscinas)

### SEZIONE A-A'


LEGENDA GEOLOGICA
DEPOSITI CONTINENTALI DEL QUATERNARIO: 4 – Depositi alluvionali terrazzati. COMPLESSO VULCANO-SEDIMENTARIO OLIGO-MIOCENICO: 10a – Ignimbriti riodacitiche; 11a – Ignimbritiche riolitiche; 12a – Ignimbriti riolitiche; 15a – Flussi piroclastici; 41 – Lave andesitiche; 44 – Basalti e basalti andesitici; 45 – Lave andesitiche; 47 – Brecce vulcaniche; 52 – Conglomerati, arenarie, siltiti, argilliti ("Formazione del Cixerri", Eocene medio-? Oligocene inf.) (da Assorgia et al., 1992).
GEOLOGIC LEGEND
QUATERNARY CONTINENTAL DEPOSITS: 4 – Terraced alluvial deposits. OLIGO-MIOCENE VOLCANIC-SEDIMENTARY COMPLEX: 10a – Rhyodacitic ignimbrites; 11a – Rhyolitic ignimbrites; 12a – Rhyolitic ignimbrites; 15a - Pyroclastic flows; 41 - Andesitic lavas; 44 – Basalts and andesitic basalts; 45 – Andesitic lavas; 47 – Volcanic breccias; 52 – Conglomerates, sandstones, siltstones, argillite ("Formazione del Cixerri", lower Eocene-? Lower Oligocene) (from Assorgia et al., 1992).

### SEZIONE B-B'




LEGENDA GEOLOGICA
DEPOSITI CONTINENTALI DEL QUATERNARIO: a – Depositi di versante; a1a – Depositi di frana; b2 – Coltri eluvio-colluviali; bna - Depositi alluvionali terrazzati prevalentemente ghiaiosi; PVM2a – Ghiaie con subordinate sabbie terrazzate. SUCCESSIONE VULCANO-SEDIMENTARIA OLIGO-MIOCENICA: CBU – Depositi piroclastici; STP – Piroclastiti ed epiclastiti; CIX – Arenarie, marne, conglomerati, argille siltose ("Formazione del Cixerri", Eocene medio-? Oligocene inf.). COMPLESSO METAMORFICO: CPI – Metacalcari, metasiltiti ("Formazione di Campo Pisano"); GNN2 – Metacalcari ("Membro del calcare ceroide"); GNN1 – Metadolomie ("Membro della Dolomia rigata"); NEB1 – Metasiltiti, metarenarie; NEB2 – Metarenarie, metasiltiti, metargilliti; NEB2a – Metacalcari (da APAT, 2009; 2012).
GEOLOGIC LEGEND
QUATERNARY CONTINENTAL DEPOSITS: a - Slope deposits; a1a - Landslide deposits; b2 – Eluvial-colluvial deposits; bna - Terraced alluvial deposits mainly gravelly; PVM2a – Terraced alluvial gravels with subordinate sands. OLIGO-MIOCENE VOLCANIC-SEDIMENTARY COMPLEX: CBU – Pyroclastic deposits; STP – Pyroclastic and epiclastic; CIX – Sandstones, marls, conglomerates, silty clays ("Formazione del Cixerri", lower Eocene-? Lower Oligocene). METAMORPHIC COMPLEX: CPI - Metalimestones, metasiltstones ("Formazione di Campo Pisano"); GNN2 – Metalimestones ("Membro del calcare ceroide"); GNN1 – Metadolostones ("Membro della Dolomia rigata"); NEB1 – Metasandstones, metasiltstones; NEB2 – Metasandstones, metasiltstones, metargillite; NEB2a – Metalimestones (from APAT, 2009; 2012).

From the standpoint of the cultural heritage, the area presents an extraordinary array of archaeological sites, from the Neolithic to the modern era, representing a unique identitary patrimony in the Mediterranean context: about 90 nuraghes, giants' graves, sacred wells, hypogean temples, two important Punic sites, *domus de janas* and *menhirs* dating back to the Neolithic, an important road built by the Romans and the remain of recent infrastructures such as the abandoned Pantaleo-Porto Botte and Siliqua-Calasetta railway lines, sites of industrial archaeology such as the Rosas, Sa Marchesa and Montega mines.

**Aknowlegments**

Work carried out at the Laboratorio di Geologia ambientale e termografia of the Dipartimento di Scienze della Terra of the Università di Cagliari (Laboratory manager: Prof. Felice Di Gregorio)

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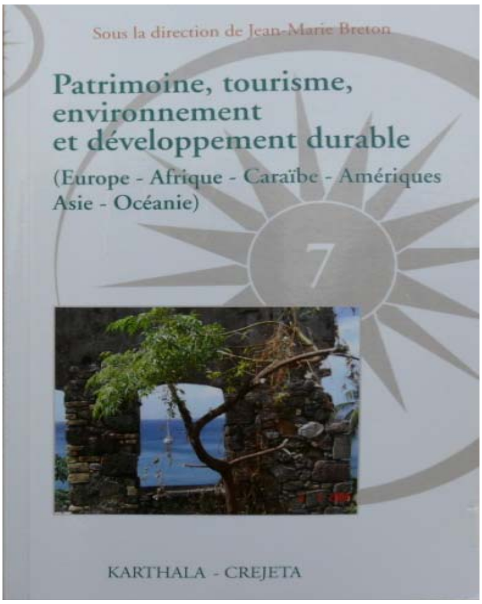
|---|---|---|
| 06.02.2014 | 07.05.2014 | 09.05.2014 |

**Book review:**


J-M. Breton (2009) (Ed.), Patrimoine culturel et tourisme alternatif, Karthala-Crejeta, ISBN:978-2-8111- 0246-3

**Patrimoine culturel et tourisme alternatif – Europe-Afrique-Caraibe-Amériques (2009)**




J-M. Breton (2010) (Ed.), Patrimoine, tourisme and sustainable development, Karthala-Crejeta, ISBN:978-2-8111-0403-0

**Patrimoine, tourisme, environment et développement durable – Europe-Afrique-Caraibes-Amériques-Asie-Océanie (2010)**

The two volumes appeared within the series *Iles et pays d'Outre-Mer /Islands and Overseas Countries*, under the careful supervision of Jean-Marie Breton, public law professor of the University of the Antilles and French Guyana and published under the patronage of Karthala-CREJETA publishing house. The series debuted in 2001 and is meant to promote researches related to the environment, tourism, international law and environment, the sea environment, land biodiversity, real estate, urbanism, planning and ecotourism with special focus on the island territories.

The sixth volume of the above-mentioned series inspected here is entitled "***Patrimoine culturel et tourisme alternatif/Cultural Heritage and Alternative Tourism***" and covers a wide range of studies (selectively-listed below) related to: the image of the public cultural heritage; directions for eco water-tourism development of Poitevin Moorland; alternative tourism strategies of the Canaries; the importance of yolas as part of the Martiniquean identity to promote tourism development in the area; the set up of the historical sugar cane park of Haiti; heritage appropriation and local involvement in the case of the Taonaba-Belle Plaine of Guadelupa; judicial aspects of the Brasilian cultural heritage; coast tourism affected by the sea water level rise in the Nouveau-Brunswick area; island case studies from the main geographical regions of the world such as Europe, Africa, the Carribean and America. The fourth part lays emphasis on the need to find the efficient legal tools for the policies' adjustment of the insulary regions to the continental ones.

The researches hereby stand as a proof that tourism has a strong interdisciplinarity, as for a better tourism planning, social, economic, political, psychological, anthropological and technological factors need to be involved so that the natural and cultural heritage can be best preserved and the tourist also satisfied, so as to avoid that inestimable and irreproducible resources do not become the victim of their own success, thus leading to their extinction.

The seventh volume "***Patrimoine, Tourisme, Environment and Sustainable Tourism/Heritage, Tourism, Environment and Sustainable Development***" is structured on four parts, such as: Cultural Heritage, Tourism and Identity Integration; Cultural Tourism and Sustainable Tourist Development; Imaterial Heritage, Monumental Heritage and Alternative Tourism; Territorial Heritage and Sustainable Development, all chapters including case study researches related to these topics from Europe, Africa, the Carribbean, Americas, Asia and Occeania.

Sustainable tourism has gained much interest in tourism reseraches lately, as local communities become ever more involved and concerned about how tourism is influencing their existence on the long term, because not only is the material heritage fragile to overconsumption or mis-use appropriation as the imaterial one is even more vulnerable. In order to preserve the latter, certain communities have resorted to a certain "*museification*" or folklorisation. Such is the case of the cultural communities of the Wayana Ameriendiens and the Aluku bushimen, mainly the latter ones who, by their dislocation of their native places, have foresaken or lost the knowledge of creating a material or imaterial production which would allow the reproduction of their culture.

A "*patrimonialisation*", a step taken to capitalize and protect the material goods, spaces and cultural values in a sustainable manner needs to be set in place for the community's benefit. Certain authors consider as sustainable the small-scale tourism, or otherwise referred to as inteligent or alternative turism and propose ecotourism it as a means to protect peripheric fragile communities networked into the globalisation pattern, as in the case of the Wallis et Futuna territory enclaved within the Pacific. On the other hand, seen more indugently, large-scale (mainstream) tourism could function as a tool to alleviate poverty in certain territories, as in the case of the Penarik, Terengganu, Malaysia, meanwhile consolidating the linkages with the local economy and people within it.

Local people's collocation with archaeological sites are very important, as archeology is included within the cultural heritage and it is important to view it as less pertaining to science and more dynamically and contextually to the local community, an issue also debated within the book.

Ecotourism preservation is another issue hereby approached in the case of North Vietnam which takes heed that both residents and local guides need to be trained, meant to educate tourists to respect the protected areas and ecotourist sites. Biodiversity and unspoilt nature represent by themselves alone tourist destinations, a quarter of Costa Rica territory is covered by protected areas whose forests cover 4% of the world biodiversity, a fact which makes it a guardian of world tourism. As shown in the case of the ecotourism project Taonaba from Guadeloupa, ecoutourism can be best capitalized by a botton-up approach through participatory governance, the latter concept equally important in regulating religious tourism, which has grown in propensity to reach 27 million pilgrims who visit Mexico. Also protective measures for the South-Eastern Morroccan kasbahs, architectural sites turned intrusevely into accommodation or restauration units which could alter them irremediably, need to be taken and the authors call for a participatroy governance with all actors involved such policymakers, investors, tourists and local population.

Another signal is drawn in the case of a Unesco World Heritage site such as Machu Picchu of Peru, where local communities live at the outskits of their heritage and their income sources which come mainly from agriculture and tourism activity are highly menaced by an endemic vulnerability such as floods. Traces of the pre-colombian culture also exist in the Lesser Antilles territory and the authors propose it as a tourist product, the "*petroglyphe route*" pertaining to cave art.

The interconnection of policy, law, territorial planning and tourism is approached within the fourth chapter of the book, therefore referring to: the capitalization of the cultural heritage and planning patterns of the overseas regions; law-integrated labels in the case of the national park of Guadeloupa; territorial development and local resources capitalization of Martinica; a conceptual frame which can mainly boost comminity-based benefits and where tourism helps for a better territorial cohesion; the renaissance of the cultural African rights through the adoption of the African Cultural Renaissance Chart in 2006, but where cultural tourism is not primordial for the development policies of the heritage cultural protection nor for the cultural development policies.

Either cultural, ecological, religious, poverty tourism and all other tourism types revealed by the two volumes within the series, carried on by tourists on a large or a small scale, needs to be framed within a coherent strategic development which translates into a good governance where the community's benefits should prevail, be they from remote, popular or less known destinations of the world regions. The books magistrally highlight both positive and negative aspects of tourism as well as proposals for a sustainable tourism development, within a very-well edited standardized series which has reached its tenth volume in 2014.

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**Intensive Course on Mountain Geomorphosites**
(22-24 August 2013, Lausanne and Swiss Alps / Switzerland)

The Intensive Course on Mountain Geomorphosites was held on 22-25 August 2013 in Lausanne and Hérens valley (Switzerland) and regrouped almost 30 distinguished geomorphologists and Ms. and PhD. students from 12 countries.

The Intensive Course was organized by the Working Group on Geomorphosites (working group of International Association of Geomorphologists) and by its Chair Prof. Emmanuel Reynard from Geographical Institute, Lausanne University. The scientific activities were developed during 4 days (22 to 25 August 2013) in Lausanne (at the Institute of Geography, University of Lausanne) and in the Swiss Alps (at Hérens valley).

Generally, the main objectives of this Intensive Course were to improve knowledge and assessment of geomorphological sites, with particular emphasis on conservation, education and tourism attractivity in respect to these sites. Another important objective was to create and maintain an international network on mountain geomorphosites.


**Day 1 (22 August) -** Professor Reynard opened the meeting with a discussion about the objectives of the course (Figure A). Then, several notorious specialists on mountain geomorphosites talked about the specificities and characteristics of those mountain geomorphosites (E. Reynard – *Switzerland*, C.

Giusti, N. Cayla – *France*, Z. Zwolinski – *Poland*). At the afternoon a geoscientific itinerary prepared by the University of Lausanne and Bureau Relief (guides: prof. E. Reynard, S. Martin and G. Regolini) took place in the town of Lausanne.

**Day 2 (23 August) -** The second full day of the course, Friday, opened with a series of talks on methods of study and approaches on mountain geomorphosites (I. Bollati, M. Giardino – *Italy*, S. Martin, G. Regolini – *Switzerland*, F. Hoblea – *France*, P. Pereira – *Portugal* and I.A. Ayala – *Mexico*). At the afternoon, prof. E. Reynard organized a field trip in Lavaux, UNESCO World Heritage Site, where the participants observed the beautiful vineyards on the banks of Geneva Lake (Figure B).

**Day 3 (24 August) -** In the morning the group left Lausanne for the Hérens valley. The participants visited the Lac Bleu (Figure C), the Arolla valley and settlement and at the end of the day the commune of Evolene made a welcome reception. All the young participants presented their research projects and they exchanged their experience in various mountain ranges.

**Day 4 (25 August) -** The group left the Arolla for Ferpècle and Euseigne. At Ferpècle the participants take contact with a spectacular glacial valley and with the Mont Miné glacier (Figure D). Descending from the alpine region, the group stop to see and comment an important local géomorphosite: the Eusegne pyramid.

To conclude, the outstanding themes of the course which were very good analyzed were: (1) study of the specificities of mountain geomorphological heritage, (2) presentation and discussion of methods used in geomorphological heritage research, (3) networking of young researchers active in géohéritage studies and (4) exchange of experiences in various mountain ranges.

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