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THE ERNICI MOUNTAINS GEOHERITAGE (CENTRAL APENNINES, ITALY): ASSESSMENT OF THE GEOSITES FOR GEOTOURISM DEVELOPMENT

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Abstract: In this work we propose a new model for the inventory and evaluation of a part of the Ernici Mountains (Trisulti of Collepardo) geosites. The aim of this work is the enhancement of cultural landscape, through a geotourist itinerary describing the culture as the product of the interaction between humans activities and their living environment. To this aim, the enhancement of the geoheritage is based on the landforms analysis and the observation of culture as a landscape-modeling agent. The proposal for the assessment of the Value of a Site for Geotourism (VSG index) was made by means of the integration and review of national and international geosites evaluation models. Infact, the aim of this work requested to build up a model focused on the geotourist relevance of the geosites. The Ernici Mountains are representative of the italian Central Apennine carbonate platforms. The outcropping lithologies influenced the development of the karst. The abundance of karst cavities inspired the spirituality of many hermits. The monastic culture contributed to the evolution of the peculiar cultural landscape of Trisulti. The itinerary proposed describes the related geomorphological and cultural most significant aspects.

Key words: geotourism, cultural landscape, evaluation model, Ernici Mountains geotourist itinerary.

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INTRODUCTION

The conservation of natural heritage represents a basic topic in biodiversity, but in recent years attention towards the geological environment, as substrate of life, increased.

In Italy the geodiversity and the geosites are considered cultural goods (DLgs n.42 2004, Urbani Codex; 431/85 Law, Galasso Law; DLgs n. 490/99: n. 352 Art. 139), they

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compose the Geological Heritage of the country. The geotourism represents the most recent and sustainable way to enhance this resource, through the popularization of geo-scientific knowledges, along itineraries describing the natural, historical and cultural features of the territory.

In this work we present the inventory and evaluation of a part of the Ernici Mountains (Trisulti of Collepardo) geosites and a new geosites evaluation model. The aim of this work is the enhancement of Cultural Landscape (Sauer, 1925; Andreotti, 1998; Gordon, 2012) and the popularization of the natural and cultural resources of the area, through the proposal of a geotourist itinerary, describing the culture as the product of the interaction between human activities and the natural environment.

MATERIALS AND METHODS

Analysis of the morphological features and changes

The analysis of landforms was made by means of a geomorphological field survey; the information about morphological changes in a longer time interval was supported by the aerial photos interpretation (Italia RER 1988/1989; I.G.M. GAI, 1954/1955). Following several authors criteria (Panizza, 1973, Pellegrini, 1976; Dramis et al., 1979; Gruppo Nazionale di Geografia Fisica e Geomorfologia, 1994, 1995; Aringoli et al., 2005), the morphological elements in the study area were grouped according to genetic criteria, so each landform was classified according to the main morphogenetic process that was responsible for its origin.

The geosites inventory and evaluation model

A new evaluation method is proposed and applied to evaluate the geosites for geotourism development. It is based on the integration and review of some models proposed by the Lazio Regional Park Agency (Fattori and Mancinella, 2010), Reynard et al., (2007) and Ghiraldi (2011). The authors intervention consists of modifing and adding the evaluation of some geosite attributes to build up a model focused on the evaluation of the geotourist relevance of the sites.

Among the several attributes which could be quantified, according to the most frequently encountered definitions of geotourism (Hose, 2012 and references therein; Newsome et al., 2012; Arouca Declaration, 2011 in geoparquearouca.com), can't miss the attributes summarized in the new index proposed, the Value of a Site for Geotourism (VSG) index:

$$\mathbf{VSG = RP + RR + SCE + SAC + AC}$$

$VSG_{max}=25$

1-8 low	9-16 medium	17-25 high

The attributes are Representativeness (RP), which is the correspondence between the geological phenomenon represented in the geosite and the ideal model of the same geological phenomenon and it also defines the geosite pecularities and plurality of interests; Rarity (RR), the relationship between frequency of a geological aspect and the geographical setting of analysis; Scenic-Aesthetic value (SCE), that quantifies the attractiveness of a geosite from a geo- specialist and non-specialist point of view, and is an attribute of prompt comprehension for the enhancement of an area, but at the same time is difficult to quantify, because much tied to the emotional; Storical-Archeological-Cultural value (SAC) function of the geosite relationship with local history and culture; the Accessibility (AC) depends on the difficulty to reach a site and the presence of nearby services.

Each value represent a class, corresponding to an interval, obtained summarizing scores. The scores are collected compiling some tables describing geosite characteristics (Figure 1). The evaluation is aimed to remove the subjectivity of the selection procedure and confers a value to the analysis of the geosite characteristics.

VALUE OF A SITE FOR GEOTOURISM			
VSG= RP+ RR+ SCE+ SAC+ AC VSGmax=25			
ATTRIBUTES		VALUES	
REPRESENTIVENESS RP		0,1,3,5	
	Ideal model correspondence	5,3,3,1,0	
	Peculiarity (lithostratigraphy, carsism, hidrology, paleonthology, geomorphology, structural geololgy, mineralogy)	5,3,3,1,0	
	Tipicality	5,3,3,1,0	
	Interest plurality	5,3,3,1,0	
RARENESS RR		0,1,3,5	
	Geographical range	local, regional, national, international	two way table
	Frequency	5,4,3,1,0	
SCENIC AESTHETIC SCE		0,1,3,5	
	View points	5,3,1,0	summarize intervals [...]
	Cromatic contrast	5,3,1,0	
	Landforms queerness	5,0	
HISTORICAL-ARCHEO-CULTURAL SAC		0,1,3,5	
	National restrictions (laws)	3,5 (area, geosite)	summarize intervals [...]
	Regional/local restrictions (laws)	1,3 (area,geosite)	
	Protected area	3,5,1	
	Other (archeol., monum., architett. values; legends, stories, tradition; toponym)	2,2,1	
ACCESSIBILITY AC		0,1,3,5	
	Way to approach the site	5,3,1	summarize intervals [...]
	Difficulty to approach the site	5,4,3,1	
	Services	5,4,3,1,0	

Figure 1. Schematic synthesis of the evaluation model

The integrations to the base model involves:

• some aspects included in representativeness (RP) evaluation has been redefined; the relationship between frequency of a geological aspect and the geographical setting of analysis is a new proposal for rarity (RR) evaluation; sub-attributes describing the scenic value (SCE) of a site are integrated from other models (Reynard et al., 2007; Ghiraldi, 2011) and “peculiarity of the forms” has been introduced as a new characteristic ; the evaluation of historical, archaeological and cultural value (SAC) of the site has been included in the geosite evaluation; the difficulty to reach a site and the presence of nearby services are the sub-attributes for the accessibility (AC);

• the card has been reviewed to facilitate the understanding for "non-specialists" users.

• finally, when compared to other evaluation models (Serrano & Gonzales Trueba, 2005; Pereira et al., 2007; Fattori & Mancinella, 2010; Coratza et al., 2012; Bollati et al., 2012), the Value of a Site for Geotourism doesn't weigh the different attributes. Infact, scientific attributes of the geosite are as important as additional ones, as the definition of geotourism wants (Arouca Declaration, 2011 in geoparquearouca.com).

THE STUDY AREA

The Ernici Mountains are a carbonate ridge in the South East of Lazio region (Italy), not too far from Rome. The ridge is NW-SE oriented and a long section corresponds with the regional bound between Lazio and Abruzzi regions (Figure 2).

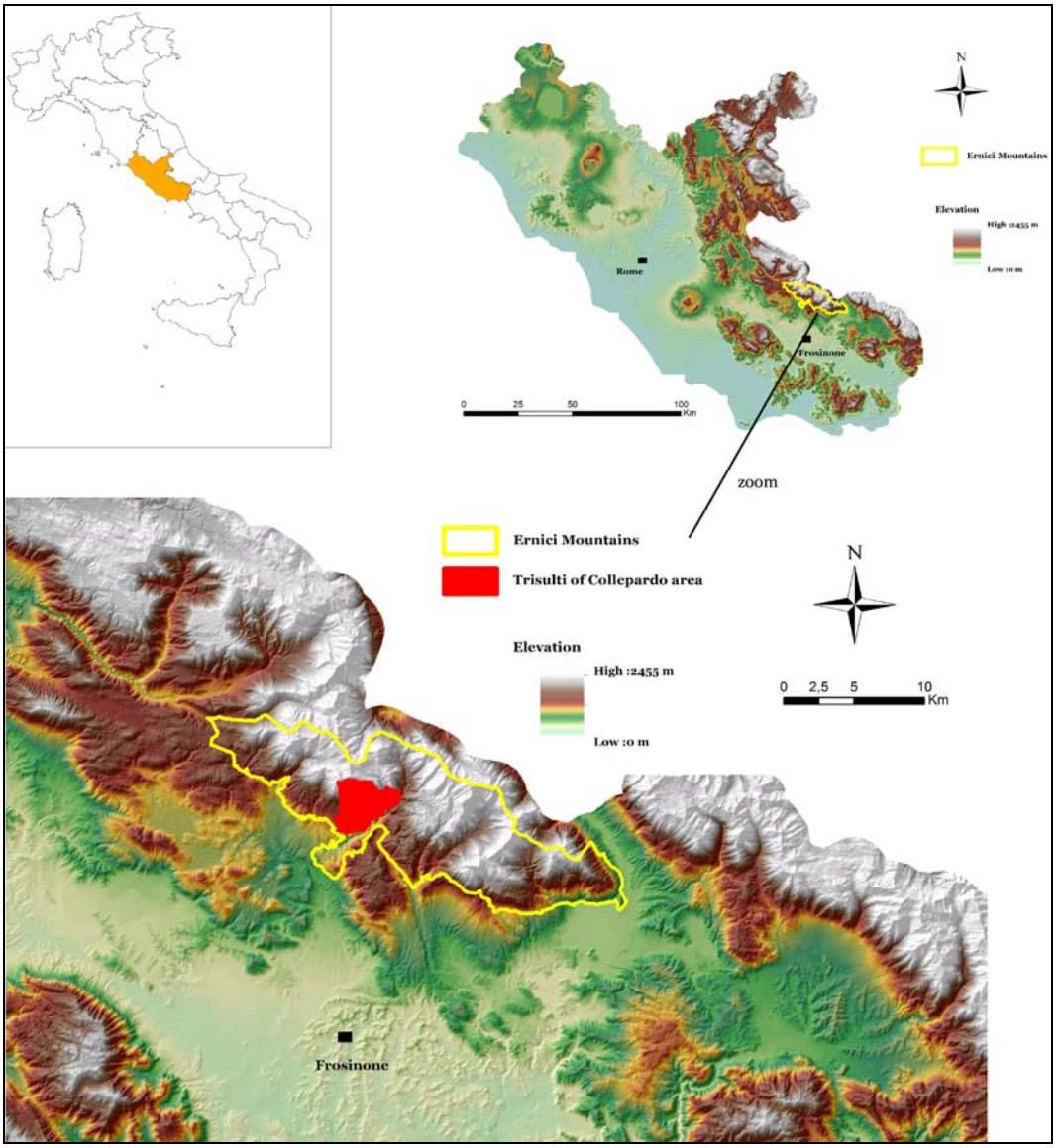

Figure 2. Location of the study area

It represents a significant geological feature of the Apennine's uplift and an important part of the Lazio-Abruzzi carbonate platform (Parotto & Praturlon, 1975; Accordi & Carbone, 1988). Here Mesozoic limestones (Lias-upper Cretaceous), with dolomite banks, emerged by the sea since the Middle Miocene.

The area is also an important scenary for the cultural history of Lazio region's countryside. The study area, Trisulti of Collepardo, is a portion of the ridge (Figure 2).

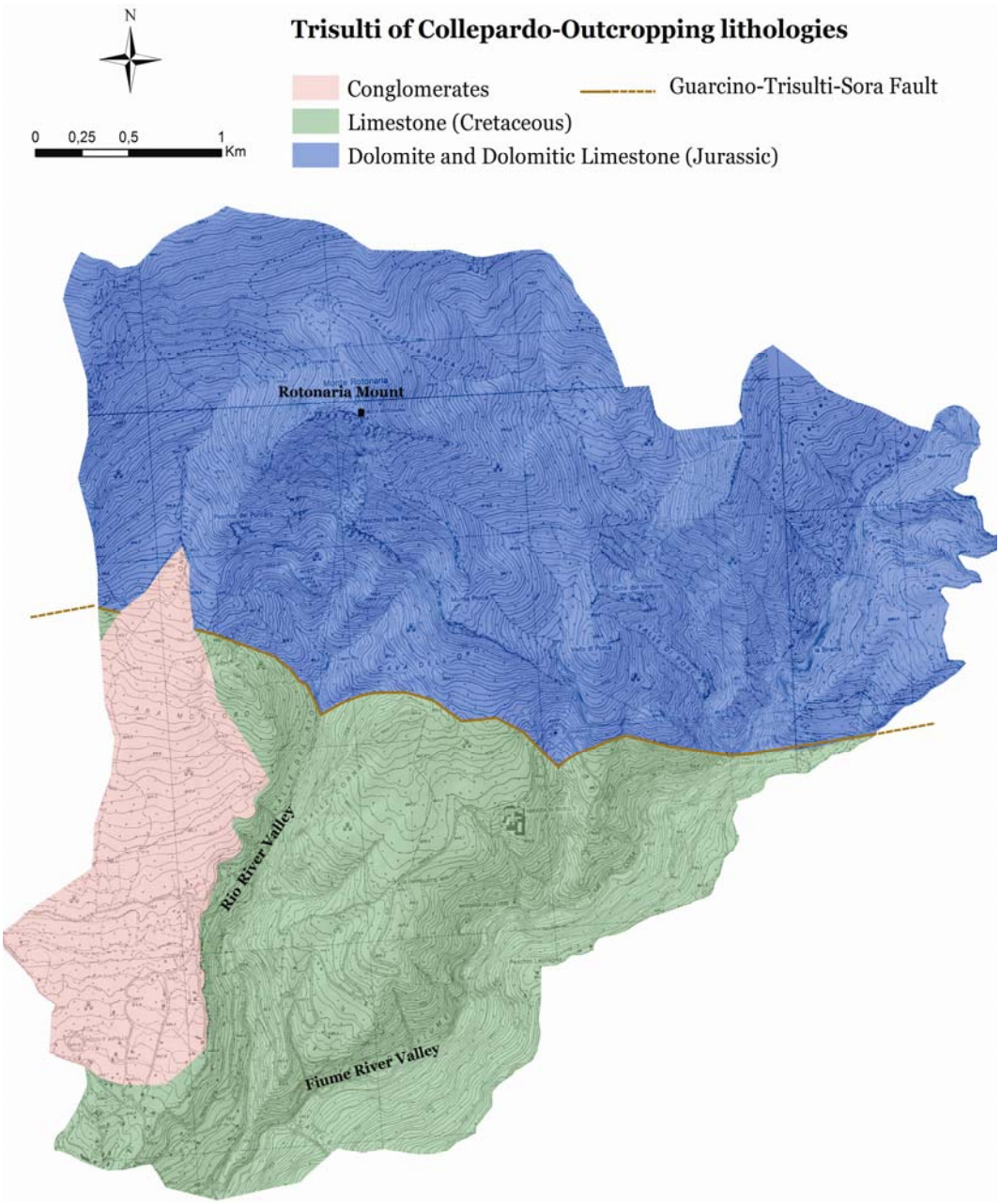

Figure 3. The outcropping lithologies and the normal fault crossing the area

It covers 15 km^2 of the 200km^2 pertaining to the whole Ernici Mountains, and its altitude ranges from 550m to 1744m a.s.l. (Rotonaria Mount). A normal fault (Guarcino-Trisulti-Sora fault, NW-SE strike) (Cavinato et al., 1990) crosses the area separating the outcroping lithologies in two sectors (Figure 3): the upper sector is characterized by the more ancient rocks outcropping, represented by Lias dolomite and dolomitic limestones, and a powerful Jurassic limestones succession (Dogger-Malm); the lower sector oucrops are represented by Upper Cretaceous limestones and Middle Cretaceous dolomitic limestones (Cavinato et al., 2012).

The outcropping lithologies and the tectonic evolution of the area influenced the development of landforms. The Apennine extensive tectonic caused the rocks strong fracturing and the karst development: the superficial and hypogean process is still now widely spread.

The erosion deeply affected the carbonate rocks and widespread gravitational processes occur on the slopes. The fluvial network organization is often influenced by structural directions. Some glacial landforms, developed during the last glacial period, are present on the highest peaks.

Two drainage basins characterize the area: the Fiume and the Rio River basins. The Rio stream born from its homonymous spring (Capo Rio, 830m), next to the Guarcino-Trisulti-Sora fault. It carves a short deep valley, NNE-SSW oriented, in the cretacic limestones. The Fiume River main spring is the Capo Fiume one (940m); its valley, NE-SW oriented, is cut for a long stretch in the Jurassic dolomitic limestone, that are hardly fractured and affected by karst phenomena; the Fiume river valley also cuts the Guarcino-Trisulti-Sora fault where it start cutting the Cretaceous limestones.

The fluvial erosion system strongly influences the morphodynamics in this area.

RESULTS

The study area is characterized by landforms shaped by the action of: surface running waters, karst and gravity, even if antrophogenetic processes cannot be disregarded. Polygenic and structural-landforms are also present. Some of these landforms are proposed as geomorphosites (Panizza, 2001).

Landforms

Surface running water landforms

The Rio and Fiume valleys present a deep V-shaped section, thus testifying the clear prevalence of linear erosion on accumulation processes. The riverbank erosion is not particularly accentuated, as fluvial erosion scarps never exceed 5m.

In its upper course, the Fiume River flows along a fracture in the Jurassic dolomite-limestones, for a distance of 300m. Large boulders, due to collapses, articulate this stretch of the stream in rapids. Here are some dramatic landforms, as the Arch in the rock (geomorphosite), a cavity deepened by the river flow, and the deep gorge named La Stretta (Figure 4).

The run-off action affects the slopes of the Rio stream basin, especially on cataclasic outcrops. The accumulation landforms due to the surface running water are represented by some alluvial fans: a huge pleistocenic one, at foot of La Monna Mount, covers plentifully the the ancient erosional surface west of the Rio valley (Figure 4).

Karst landforms

Limestone is the main outcrop in the area, so the karst landforms are widespread. The surface is everywhere affected by karren (lapiez); there are a number of small dolines and a deep sinkhole just outside the study area (named 'Pozzo d'Antullo'). It witnesses a great development of hypogean karst processes.

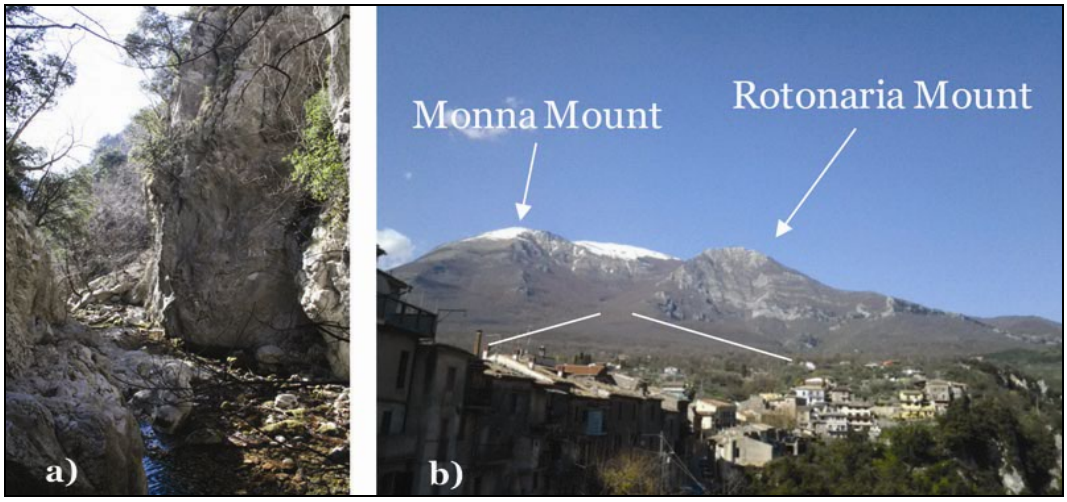

Figure 4. a) The gorge named "La Stretta", the italian for narrow valley;
b) the pleistocenic alluvial fan at the base of La Monna Mount

Figure 5. The Madonna delle Cese sanctuary in a); in
b) the organ pipes and stalactites in the cave; in c) the ancient hermitage

Along the upstream sector of the Fiume valley there are several karst caves. The smallest corresponds to S. Domenico hermitage and big one is the Madonna delle Cese cave (Figure 5).

On the cave surfaces are still visible organ pipes, stalactites and stalagmites. The Arch in the rock, nowadays crossed by the Fiume stream channel, is a relict hypogean karst landform: it was a pressured karstic pipe of an ancient karstic underground drainage network. Other cavities around the Arch testify to the presence of an ancient underground net (Figure 6).

Gravitational Landforms

The area is not particularly affected by gravitational phenomena. However, mass movements are sometimes enhanced by the intense rock fracturing and the presence of cataclasic material along the fault belt. The southern slope of Rotonaria Mount is deeply

furrowed by debris-flows, which caused, at their base, the related deposits.Other gravitational evidences in the area are essentially accumulation landforms, as talus slope.

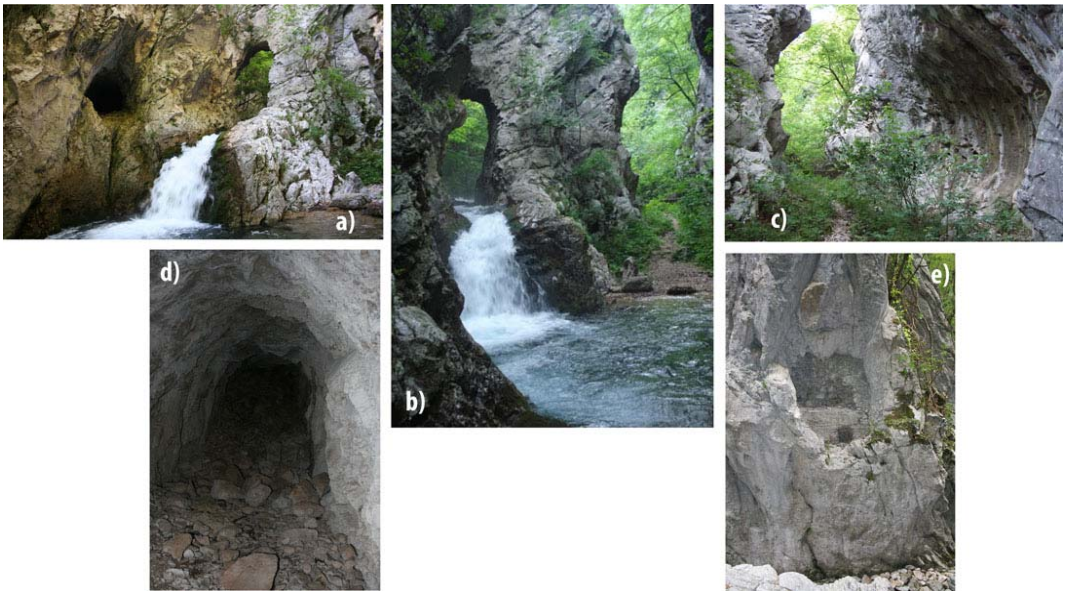

Figure 6. The pressured karstic pipes of an ancient underground network: a) the Arch in the rock and a small dry pipe; b) and c) the Arch in the rock and the biggest pipe, which was crossed by the river until the acqueduct construction; d) a detail of the dry pipe; e) another small dry pipe, walled up during the acqueduct construction

Structural landforms

The morphogenesis of many landforms in the area is influenced by the structure. Tectonics uplifted the area and built a complex relief, with high slopes north of the Guarcino-Trisulti-Sora fault. The two sectors displaced by this fault are connected by a large cataclasic belt. Very interesting is the ridge of Rotonaria Mount, shaped like a horseshoe with vertical scarps. Sharp crests and many saddles characterize the relief; it should be emphasized the structural influence by a number of triangular facets, like this having its apex next to the crest on the left of S. Domenico.

Man-made landforms

The area has a strong naturalness, though the evidence of human presence for a long time is still recognizible. The resource exploitation is evident: spring waters are often collected (for example, the Capo Rio and the Capo Fiume springs); the presence of bituminous materials outcropping in S. Domenico area developed the mining activity for a short period; the same zone has been used for quarrying activity (cataclastic material).

The performed geomorphological investigations and the analysis of the available literature about the area revealed several interesting items on its geological heritage and allowed us to propose some geosites.

Geosites

The italian Institute for Environmental Research and Protection (ISPRA) since 2008 provide the national geosites inventory (sgi.isprambiente.it). Each region is delegate to work to its own territory. The Lazio Regional Park Agency (ARP) provided the geosites inventory of the Lazio region. They recognized more than 400 sites of geological interest, but the ARP work was more detailed into protected areas.

The Ernici Mountains are part of the Monti Simbruini-Ernici Special Protection Zone (ZPS IT6050008, Directive 79/409/CEE, DGR n.699, 2008). The ARP inventory recognized only some geosites suggested in scientific literature. The geomorphological survey performed in this work allowed us to propose two geomorphosites to be add to the regional inventory. The landforms proposed as geomorphosites present scientific value, but also scenic-aesthetic and storical-cultural one. We propose them for their representativeness, rareness, and, thus, for their geoturistic interest.

The geomorphosites proposed are: the Arch in the rock and Madonna delle Cese cave. Below, the description of the inventory and evaluation data.

Arch in the rock

Location: Italy, Lazio Region, Trisulti-Collepardo (Frosinone)
Geographic Coordinate: UTM WGS84 41°47'09.15" N 13°24'52.56" E
Altitude: 770m a.s.l.
Scientific Interest: Geomorphology
Reason of scientific interest: fluvial erosion, development of a hypogean karstic network
Contextual Interests: Scenic-aesthetic, hiking tourism
Description: The Trisulti Arch Rock geosite is represented by a natural arch in the rock (Figure 6), crossed by the Fiume river. Along its short course, the stream is deepening the gorge of La Stretta, excavated in Jurassic limestones. The initial part of the gorge is characterized by rocky cliffs with karst cavities: the hypogean karst (pre-Wurmian) had organized an underground network of pressurized pipes, which shaped in the rock the typical fusiform and "keyhole" landforms due to hypogean karsism.

The Fiume river once flowed at a higher altitude, cutting the limestones within which it was evolving the underground karst network. At the end of the last glacial period, the Fiume river has produced an intense fluvial erosion, which downcutting deeply the bedrock and intercepted the underground network. So, the arch in the rock through which today the river flows is what remains of a pressure pipe of the ancient pattern. The pressured pipe had a circular section and it flowed into a more great conduct, that is recognizible on the left bank (Figure 7).

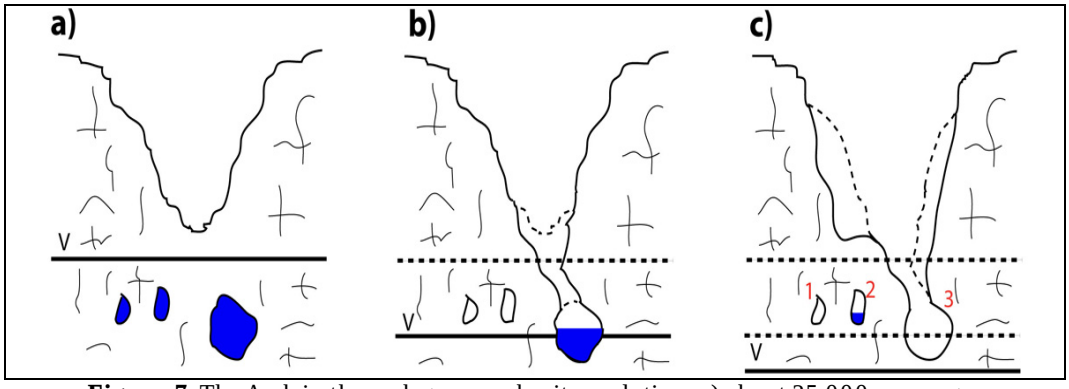

Figure 7. The Arch in the rock geomorphosite evolution: a) about 25.000 years ago; b) 3-4.000 years ago; c) nowadays. The line (v) represents the top level of the water table. The cavity 2 is the Arch in the rock, what remains of the pressured pipe. Nowadays the river flows accross it and the main channel (cavity 3) is dry because the acqueduct construction drift the water

Geosite evaluation: the site presents a medium-high representativeness value (RP= 4) due to the well defined geomorphological processes acting. The landforms are

easily recognizible and the site presents a plurality of scientific interests. It is rare if related to a regional geographical setting (RR=3) and of course it presents very spectacular and peculiar forms and an interesting chromatic contrast, due to water, rocks and vegetation presence (SCE= 5). The cultural value (SAC=1) is due to the restrictions being in force in the area, which is part of the natural heritage (natural goods are part of the cultural heritage of Italy). The geomorphosite is very accessible on foot or mountain bike and tourist services (food service and rest stop) are very close (AC=3).

VSG=4+3+5+1+3=16 The geomorphosite has a medium value for geotourism.

Madonna delle Cese cave

Location: Italy, Lazio Region, Trisulti-Collepardo (Frosinone)
Geographic Coordinate: UTM WGS84 41°46'36.25" N 13°23'42.72" E
Altitude: 727m a.s.l.
Scientific Interest: Geomorphology
Reason of scientific interest: karsism
Contextual Interests: Scenic-aestethic, Historical-Cultural,
Description: The geological site is represented by a karst cave whose wall side collapsed, due fluvial erosion (Fiume river) at the base of the slope. The cave presents numerous organ pipes, stalactites and stalagmites. The huge size of the cave allowed the construction inside of the chapel of Madonna delle Cese (Figure 5). This cult and the name are related to an apparition of the Mother of God (Madonna) to the hermit who inhabited the cavity in the VI century a.D.. The name 'Cese' is due to aspects of the surrounding landscape, such as the use that was made of the wood (copse, 'ceso' in latin) or due to the local name attributed to the places of livestock forage ('cese', indeed). These elements enrich the site of cultural and historical interests. the conservation that makes the places, linked to the cult.

Geosite evaluation: the site is very representative of the karst process, it presents a plurality of interest and the toponym testifies the importance of the site for local people over the centuries (RP=4). It is not very rare because there are a lot of karst caves in the area (RR=2). The landform is very huge and it is visible from several points of view, that increase its scenic value (SCE=5). The cultural value is related to the restriction in force in the area and of course to the cult and traditions aspects (SAC=3). A cart track allow to easily reach the geomorphosite (AC=3). VSG=4+2+5+3+3=17

The geomorphosite has a high value for geotourism.

Itinerary

Period all the time, not conditioned by the season.
Distance 4km, 150m climb, (alternate on foot and bike or car)
Duration 3 hours
Difficulty field trip, suitable for everyone

The geomorphosites resulting in this study inspired the proposal of a geoturist itinerary, which is a synthesis of the Cultural Landscape of the Ernici Mountains.

The itinerary "Hermitages and spirituality of Trisulti karstic landscape" goes along the Fiume river deep valley, in the core area of Ernici Mountains. The carbonatic slopes of the valley show lots of karstic caves: here, the abundance of cavities inspired the spirituality of many hermits, who inhabited the area since the VI century a.D., starting a monastic culture that led to the Carthusian Monastery of Trisulti (Figure 8) foundation and to the birth of several spiritual communities in the area. The itinerary description below gives indications about the most significant stops of geological-geomorphological, natural, historical and cultural interest.

Figure 8. The Carthusian Monastery of Trisulti. Background the Rotonaria and Monna Mounts

Hermitages and spirituality of Trisulti karstic landscape

Collepardo is a village not too far from Frosinone town (Lazio region), about 60 km southeast of Rome. Trisulti is a suburb of Collepardo, its name has a latin origin: *tres saltibus* means three passes, like the three passes characterizing the landscape of this place (Gregorovius, 2007). The itinerary starting point is the large parking in front of the Trisulti's Chartusian Monastery (Figure 9 point 1). The Monastery stands on a wide levelled surface, overlooking the deep carved Fiume river's valley, in a hardwood oak forest. In the hardwood forest starts the path which conduce conduces in 20 minutes to a vertical limestone cliff on which is a big karst cave (geomorphosite).

The track is cobbled to facilitate the visit of the Madonna delle Cese sanctuary, build inside the cave (Figure 9 point 2). The tradition tells about the Mother of God appearance to the hermit who inhabited the cave in the VI century a.D., for this reason the place became a pilgrimage site.

The hermitage was a very popular phenomenon in the centuries before 1000 a.D. The Trisulti area hosted lots of hermits because of the numerous caves along the Fiume valley and they founded a spiritual community, under the rule of S. Benedictus. In the XIII century Innocenzo III Pope replaced the Benedictine community, which lost its spiritual values, with a chartusian community, under S. Brunus rule (Taglienti, 1984). The Chartusians built the sanctuary in the cave, among stalactites and stalagmites, to welcome pilgrims. The cave has a very complex geomorphological evolution: there is a strike-slip fault between the monastery and the sanctuary- It was probably built into a close cavity, but the Fiume river deepening caused downfalls that opened the cavity; stalactites, stalagmites, columns, organ pipes and cauliflower concretions are still visible on the rock walls. There are other cavities around the biggest one, vertically enlarged along depositional strata and fractures in the limestones.

The itinerary goes back to the Chartreuse to visit it. It was found by Pope Innocenzo III in 1204 and it presents invaluable works of sacred art: frescos reproducing historical

events, a pharmacy of the XVIIth century, preserved as a national monument, and a well supplied state library. The church courtyard overlooks the deep carved Fiume river's valley, enclosed between two ancient levelling surfaces (Figure 9 point 3). By this view point we can analyze the relief: behind our shoulders, the Mount Rotonaria shows its vertical rock face (Figure 4), at its base the levelled surface, on which the chartreuse stands, unexpectedly breaks the pendence, it is the outcome of the Guarcino-Trisulti-Sora fault passage at the base of Rotonaria Mount.

After visiting the Chartreuse, the itinerary continues to the S. Bartolomeo monastery ruins and the S. Domenico hermitage (Figure 9 point 4), another hermit example in the valley: Domenico from Foligno founded the spiritual community in 999 a.D., nearby his hermitage, a little cave on Porca Mount, and consecrated the monastery to S. Bartolomeo apostle (Taglienti, 1984, 1987).

It is more comfortable to reach the next stop by bike or car and to stop at the bridge on Fiume river, named 'Ponte dei Santi', Sants' bridge (Figure 9 point 5). Downstream the modern bridge, lies an ancient one: it is testimony of the monasthic culture developed in the valley about the year 1000 a.D., infact the male community met here the female community founded by S. Domenico to pray together (Taglienti, 1984, 1987).

The modern bridge is the starting point of the track which leads to the Arch in the rock geomorphosite: the trail goes along the Fiume river stream and allows to see several landforms. The initial stretch is characterized by the river flow extraordinary energy, it hardly carves the bedrock: we can see several falls, vertical scarps in the rock (gorge), potholes (circular pools of limpid water) and big boulders collapsed and carried by water. When the gorge become very tight we can see the rock spike on which the geomorphosite is shaped: the water crosses the rock (Figure 9 point 6) and deep, rounded cavities testifies ancient pressured karstic pipes.

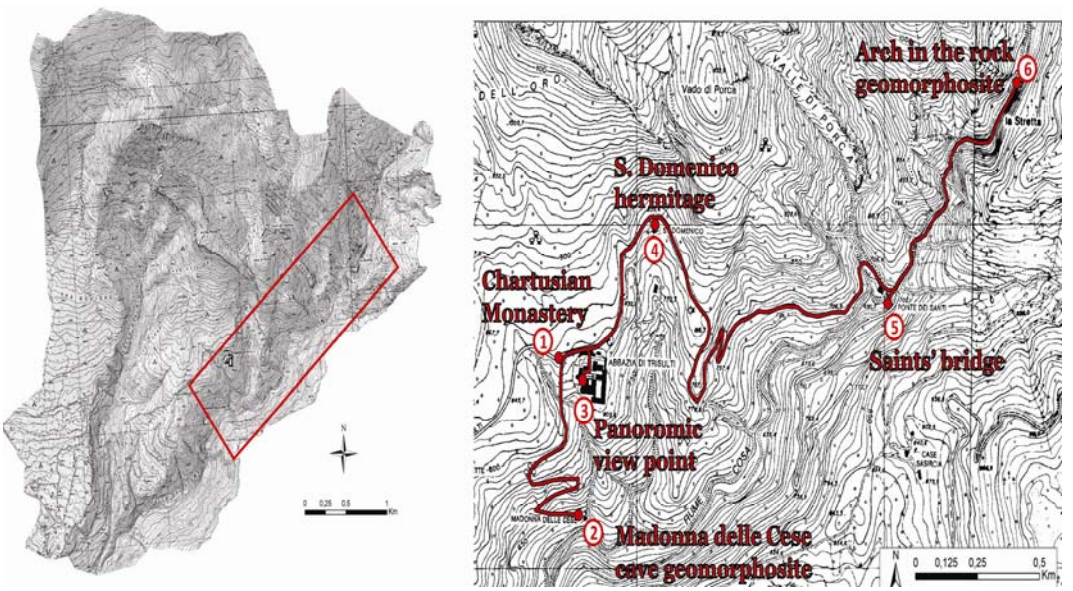

Figure 9. The area on which the itinerary develops and the track on the topographic map

CONCLUSIONS

The geological and geomorphological heritage are closely related to the cultural one: they are merged in the cultural landscape concept. The geotourist enhancement

of an area represents the most recent and sustainable way to include the natural resources in the economic development. We analized the Trisulti of Collepardo geomorphological heritage and proposed an evaluation model to quantify the geotourist relevance of sites (VSG index).

The results of the study are the development of the geomorphological knowledges, finalized to the inventory of geomorphosites, in the Trisulti area and the enhancement proposal, based on the VSG index evaluation and validation.

The enhancement of the area highlights how geological and historical sites can be enriched each other and how this link explains the connection between the physical territory and its cultural and economic development.

"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" (Viijuliie, 2014).

Trisulti is an high naturalness area, but the human presence all over the centuries is easily recognizable.

This shows the usefullness of a geotourist trail to explain the cultural landscape: the fusion of territory's cultural and natural features confers an added value to a proposal for tourism and allows the territory enhancement and nature and culture conservation.

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