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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).

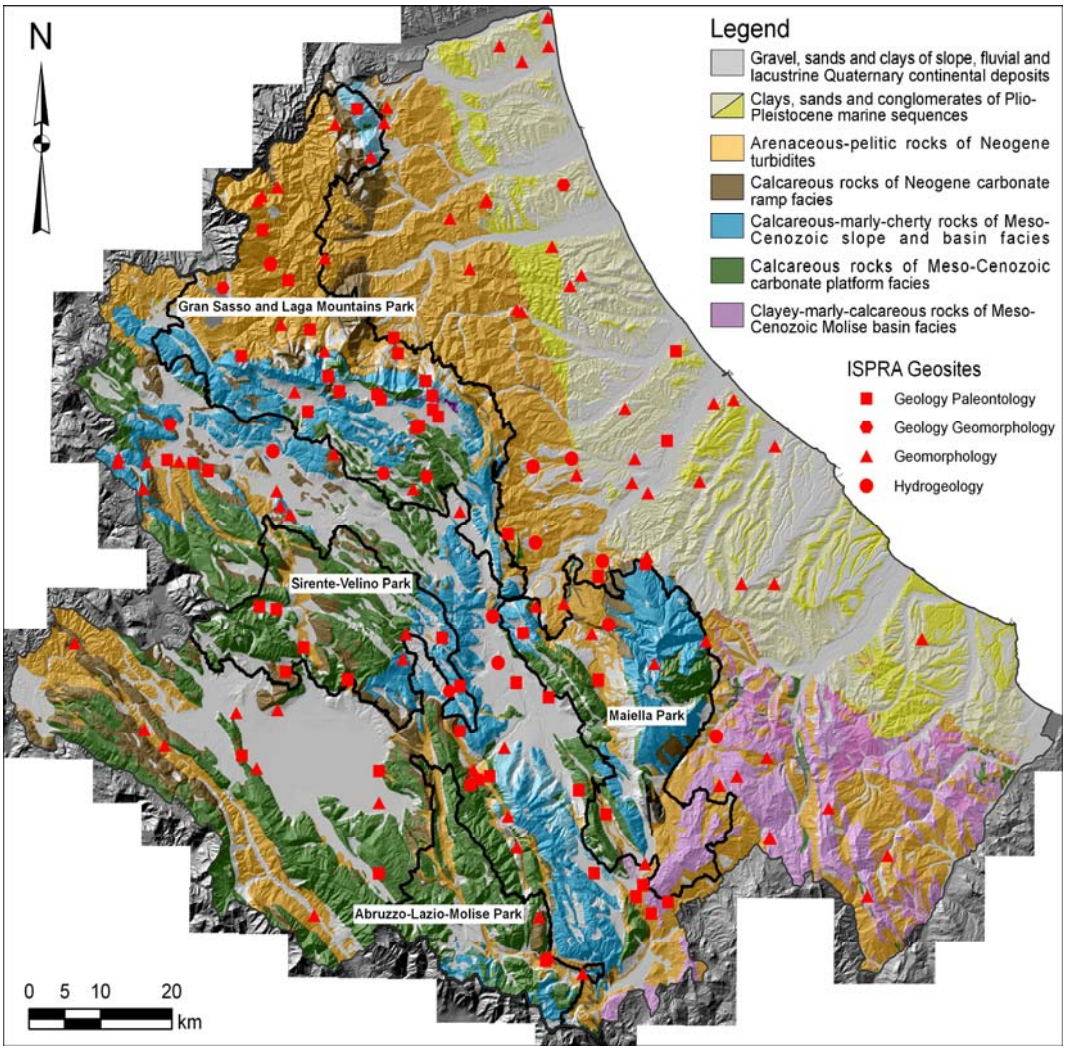


**Figure 1**. Geological setting of the Abruzzo Region and geosites from the ISPRA database (ISPRA, 2011); Black lines indicate the location of Abruzzo's national and regional parks (DEM provided by the Cartographic office of Regione Abruzzo) (Source: Miccadei et al., 2011)

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).

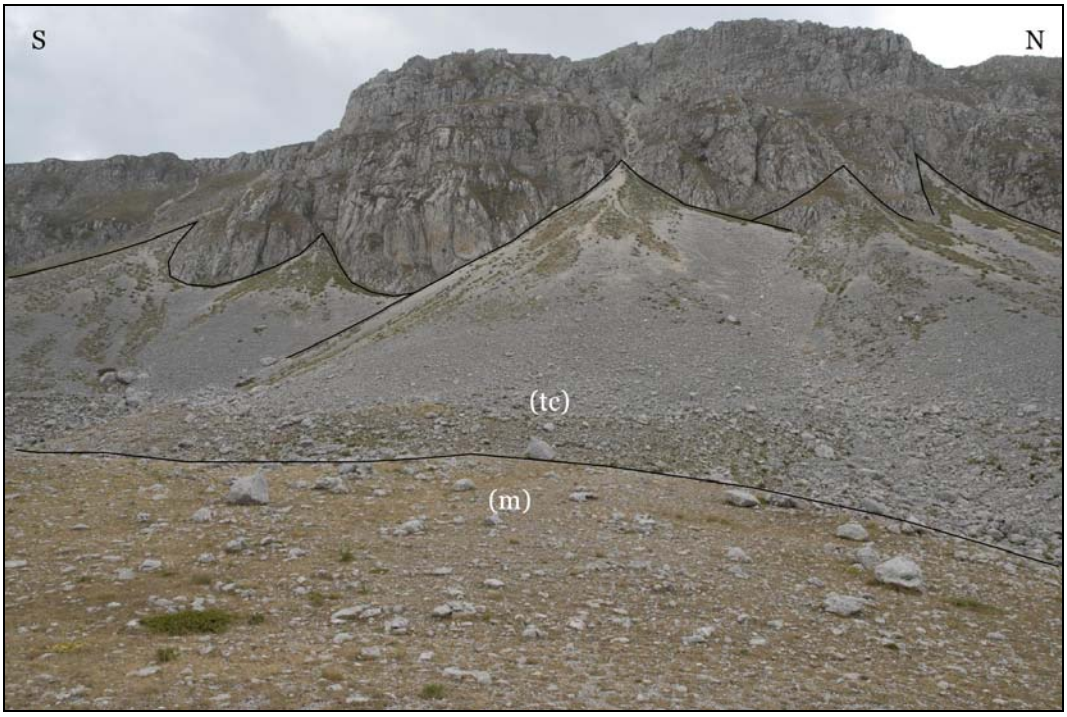


**Figure 6** – Mount Greco -St.zo Ospeduco (2071 m a.s.l.). In the foreground, glacial deposits boulders (m); in the background, calcareous scree slope deposits forming talus cones (tc) developed from a bedrock escarpment and covering ancient glacial deposits

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.

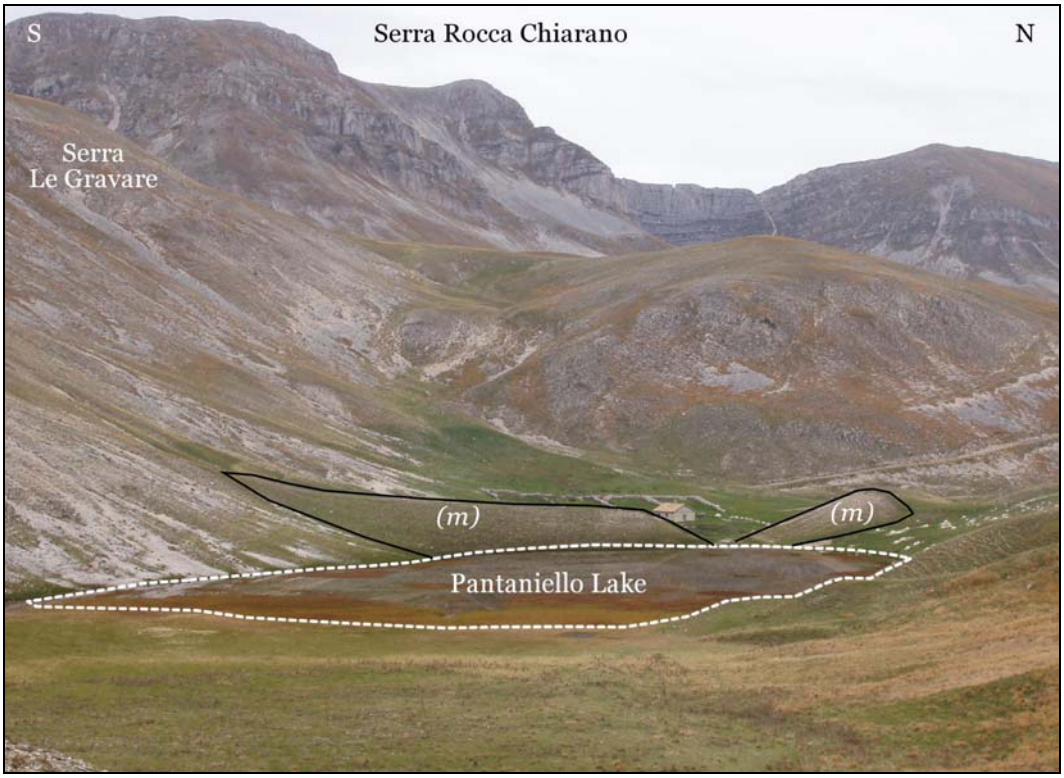


**Figure 8**. Pantaniello Lake. Morainic lake dammed by a moraine (*m*) transversal to the main valley at the base of the Serra Rocca Chiarano eastern side and Serra le Gravare slope.

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.

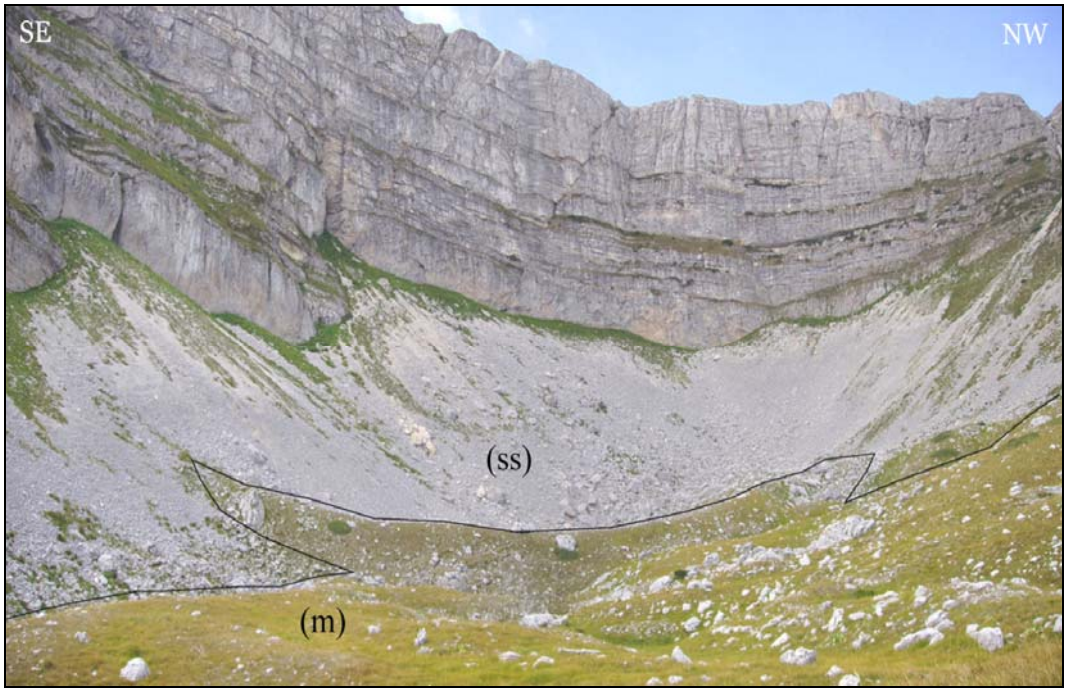


**Figure 9.** Serra Rocca Chiarano (2200 m a.s.l.)
In the foreground, glacial deposits boulders (m); in the background, calcareous scree slope deposits (ss) forming scree developed from a bedrock escarpment

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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