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Article

Geotourism through multimedia exhibition: improving the access to Urban Geoheritage

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Abstract: Multimedia materials represent a promising approach for the Geoheritage promotion. Despite Geology is normally associated with natural environments, new tendencies are projected towards a better knowledge of the "geological reason" for the location and the development of urban settlements. The urban environment is, in fact, a perfect "laboratory" for opening the scientific topics to a broad audience. In this paper the experience of a geological exhibition organized in the town of Perugia city (Umbria, central Italy) is illustrated, highlighting the SECRET (SEe and CREaTe) for an effective dissemination activity. Panels, interactive tools, laboratories and trekking tours outside the museum represent the main activities, which counted more than eight thousand visitors in a few months. Moreover, the exhibition was the starting point for ongoing projects on geotourism in the city with important consequences in terms of visibility and financial return.

Keywords: Geotourism, Geoheritage, Urban Geology

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1. Introduction: the Geotourism and the Geoheritage

Geotourism is the branch of tourism focused on activities, products and services related to the Earth Sciences [1,2] where the subject is the geological component of the natural environment and social context with a high scientific, educational and cultural value. The prefix "Geo-" encloses "geology, geomorphology, and the natural resources of landscape, landforms, fossil beds, rocks and minerals, with an emphasis on appreciating the process that are creating and created such features [1]. Geotourism links the "Geology" as a scientific discipline using objective criteria and scientific methods to "Tourism", which needs subjective criteria and aesthetic component [3]. The Geotourism is the most efficient approach for exporting the scientific contents of the Earth Sciences to a wider audience, characterized by a wide spectrum of ages and cultural backgrounds. The subject of geotourism has three main components detailed below.

The first is the Geoheritage that is a category of heritage where the geological component has characteristics of uniqueness in both the scientific and cultural aspects. These areas are selected and classified as geosites [4] and geomorphosites [5-7]. A geosite is the best expression of the Geoheritage but geosites are not always present in some areas and, moreover, their definition is not simply objective. So that in order to export the Earth sciences knowledge to a wide public it is essential to find the geological component of a landscape also in common features and daily experiences. Another measure of the geological heritage is the geodiversity and geomorphodiversity [8-10] or the variety of the abiotic component in the natural environment. Thus, although an area does not show a meaningful number of geosites, the geodiversity could be a good issue to valorize.

The second subject of geotourism is represented by the ex situ items, such as museum collections. In some contexts (urban areas) and for some samples (rare or coming from very far locations) the ex situ collections are the only key for showing particular and meaningful aspects of Geoheritage. Geoparks are the third subject of geotourism [11].

Defined the subjects of Geotourism, the real challenge is how to communicate this heritage and most of all, how to make it a "recreation activity". A huge amount of scientific papers and research

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activities are devoted to the methods and represent the main vehicle of dissemination for cultural Geoheritage [12,13]. This tendency has had an exponential growth since 2001 [11].

However, several problems arise for dissemination: among them are the technical scientific language, the geological time scale (millions of years), the spatial scale varying from extensions of thousands of kilometers to the microscopic scale [3]. Another problem is the high heterogeneity in the tourists involved in geotourism. Differences in age, cultural level and physical capability may be a serious obstacle for a successful dissemination [3].

Finally, the area of interest of geotourism does not equally cover all the branches of knowledge related to the Earth Sciences. Geomorphology, Volcanology and Paleontology are the most exploited in dissemination activities [3] since these subjects investigate more than others the macroscopic effects of geodynamics and, most of all, are linked to the most fascinating aspects of the geology, recalling spectacular and impressive natural events.

One aspect, which needs not to be underestimated is that geotourism is an important opportunity to introduce to a wide audience the concepts of geoethics [14,15] and the awareness of geodiversity as a fundamental component of the natural environment that must be known, enhanced and protected.

2. Urban Geology: from the Science to the Communication

The common idea of Geology as a scientific knowledge restricted to natural environment is quite widespread and consolidated. However an increasing attention to the geological investigation of urban areas is growing in the scientific community.

The establishment of a city has always a geological reason. The situation and the site were the initial starting points. The situation or position is the geographical location related to the surrounding areas, being fundamental for communications, economic relations and cultural exchanges with other communities. In other words the position refers to how a place is related to other cities or productive places [16]. The site conditions set the direct relations with the environmental context [16]. The topographic conditions (slope angle values in relation to the possibility of defending against external attacks) as well as the proximity of rivers or the sea, the availability of underground water, are the most important criteria for the site selection. Moreover the bedrock composition should guarantee the building material and the possibility to create hypogean cavities for a large number of uses (drainage or water supply, food storage, underground passages, shelters in case of war). The geomorphological conditions, in particular the evolution of a site in relation to landslides or flooding events, establishes the possibility for urban fabric to extend in the surrounding areas.

Thus, the knowledge of the constrains and the resources deriving from the geological characteristics, is the first step for a proper cultural approach in the city investigation.

A large part of the scientific literature was focused on the natural hazards in the cities [17]. Floods or droughts [18] and their increasing effects due to the climate change [19] are one of the topics in this area. Other specific and more local natural hazards such as volcanic or seismic events also affect urban areas [20-22].

Presently an opposite trend is growing in the scientific and administrative environments: the geological context as a new and promising resource for the touristic and didactic issues in urban areas. One of the most successful approaches is the heritage stones used for historical buildings. The identification of lithotypes and the related subjects as palaeoenvironmental conditions, palaeontological features, geological subsequent modifications provide a huge amount of hints [23,24]. In order to understand the geological composition of lithotypes outcropping under the cities or in the surrounding areas the building stones are used as point of interest for urban trekking [2]. In addition other aspects are properly used for touristic and didactic purposes. The geomorphological

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evolution perhaps represents one of the most intriguing case because, traveling through time, rewinds the morphological evolution and reveals the past, the present and the future landscape [25,26].

When the geological side joins other valences such as the archaeological one, the sites where these characteristics are present at the same time can be excellent targets for geotourism [27,28].

Once the geological aspects are known, the next step is to identify the best solution to disseminate the content. To translate the Urban Geology from a scientific perspective to a well understandable information, some criteria must be satisfied [3].

First of all is the time interval. Geology is a science that takes into account timescales of up to hundreds of millions of year (the Earth system has evolved from 4.5 billion years) while the human experience covers at most a few millennia. For common people, thinking in terms of ancient times generally means to enlarge the time perspective up to a few hundred years. The morphological evolution is perceived as something related to an unchangeable system where only the catastrophic events (earthquakes, volcanic eruptions, tsunami, landslides) suggest that the Earth is a dynamic planet. The dynamic equilibrium controlling the surface processes modeling the Earth surface is "invisible" to human eyes. This is one of the most relevant difficulty when, for example, the perceived risk is lower than the real risk during natural hazard events. Therefore, in order to communicate the geological evolution of an area is fundamental to underline the time spans in relation to human life.

The second problem is the 4 dimensional perspectives, necessary to a geologist to understand features and events. A geologist commonly faces in front of the need to track a landscape in a 3D view; in addition, a fourth dimension is needed, considering the structure under the topographic surface too. This means having the skills to "view" the landscape from a geographical perspective on the Earth surface and keeping the visualization in the vertical direction, imagining removing the topographic surface as if it were only a thin mask. This skill is not common for people with a different knowledge and therefore one of the greatest efforts that must be made to make scientific communication effective, is to introduce a tourist or a student into a "bird's eye" view and then take her/him below the Earth's surface in the fourth dimension.

The third problem is the scale. Geology includes patterns and processes that range from the infinitely large to the infinitely small. To understand the Earth dynamics, the observations embrace a spatial framework going from the solar system and beyond until the microscopic observation of the structure of minerals. The challenge is to make clear that these scales are the opposite sides of the same coin and to join the information deriving from different approaches in a unique explanation.

The fourth drawback is the language. Every experience related to scientific communication should translate the scientific language in a common one using some few but unavoidable rules: concise and without technical terms but exhaustive, in other words simple but not simplistic. To find the best compromise between complete information avoiding to being incomprehensible and boring is not so obvious.

Many experiences suppose to avoid the problem using a glossary but this is a false solution. It is quite rare that in a dissemination activity people are so intensely involved up to find an answer each time consulting a glossary and the first reaction is to read a text without fully understand it.

The fifth point, which is specific for urban geology is to never forget that in the cities the geological evolution is strictly related to human settlement, so never separate the naturalistic aspect from the anthropic one. People may be interested in the natural environment, but they become even more interest if this environment is something that has an impact in their everyday life.

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3. The "Perugia Upside-down" exhibition: an example of Best practice

Perugia is the capital city of the Umbria region, (central Italy) and is located on a triangular-shaped hill with an areal extent of about 27 km^2; the maximum altitude value is about 493m a.s.l. with a minimum of ca. 200 m along the Tiber River valley, at the bottom of the hill. The hill is distributed along five main ridges spreading from the highest altitude toward NE, E, SSE, SW, and W, separated by several small rivers. The hill of Perugia is made of sediments derived from fluvial and/or lacustrine environments, widespread in the area during the Pliocene and Pleistocene. In these periods an extensional tectonic, still acting, involved the area and the morphological expression are several intermountain basins bordered from normal faults [29,30]. Perugia is located along the western edge of the Tiberino Basin, the largest basin in Umbria (about 1800 km^2) and one of the largest in Central Italy (Figure 1).

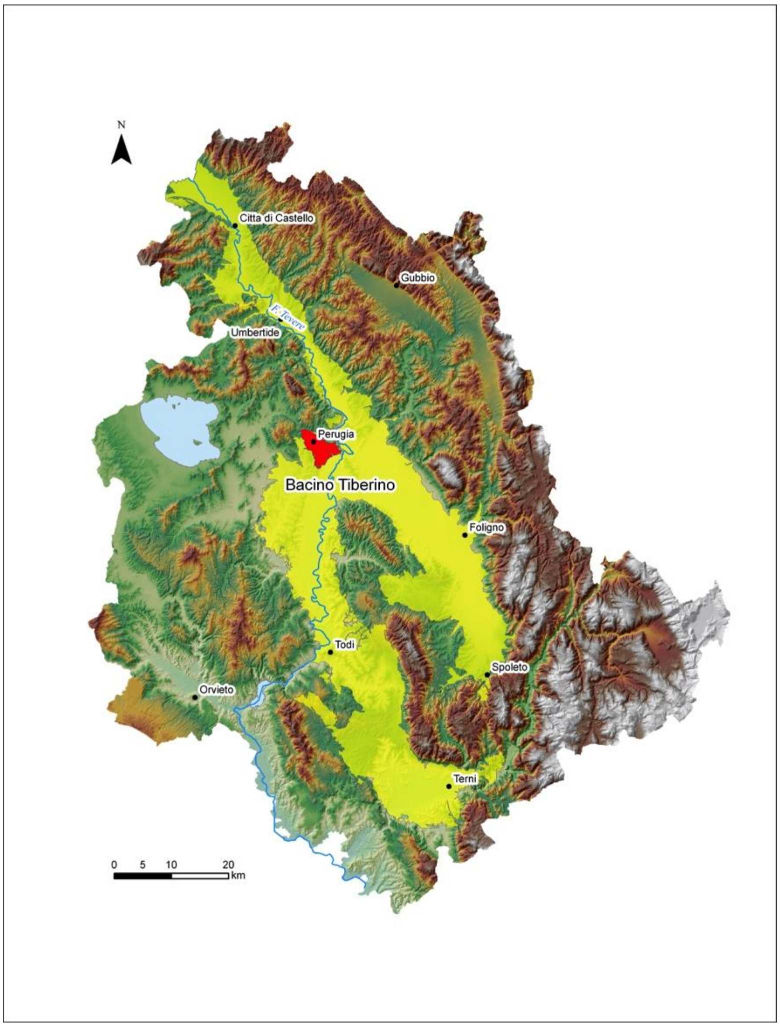

Figure 1. Location map: the Umbria region. The Perugia city is highlighted in red. The Tiberino Basin is the yellow area.

The bedrock of the hill of Perugia is made of clastic sediments of different sizes, from blocks and gravels to sands and clays. The deposits, deriving from the infilling of the basin due to the river erosion and sedimentary activity, are arranged in sequences with a variable thicknesses from few to hundreds meters. The extensional tectonics is still acting with the result that the morphological evolution is very dynamic. For this reason, the position and site location are a clear consequence of the geological history of the area. Perugia is a perfect example of a test site for Urban Geology and for the scientific communication of this topic.

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"Perugia Upside-down: when the Geology describes the City" is the title of an exhibition realized by the Department of Physics and Geology of the University of Perugia, inaugurated on 10 November 2017. The exhibit location is the POST Museum (Perugia Officina della Scienza e della Tecnica - Perugia Science and Technology Laboratory), the most important and visited scientific museum in the city. The exhibition lasted until the spring of 2018.

Exhibition is a common and useful practice in order to attract people but the results in terms of number of visitors or level of satisfaction are not always encouraging [3]. Problems are related to the traditional method of exposition (samples and description). With this aim in mind this exhibition was prepared in synergy between researchers, designers and museum workers. In particular the exhibition was structured with a basis of panels in the museum but with several parallel activities: tools, laboratories, trekking tours with the aim of encouraging visitors to become active subjects.

3.1. The path: sections, panels, tools

The exhibition was structured in five sections, each one devoted to a particular aspect of Urban Geology present in Perugia: Geology, Geomorphology, Human presence, Building stones and Paleontology. In the geological section the bedrock composition and the geological evolution of the area were summarized. In the geomorphological one the attention was focused on the morphology of the hill and on the mass wasting and fluvial processes acting on the area with an in-depth analysis of related natural hazards. The human presence was linked to the abiotic component highlighting the water supply methods and most of all, the topographic surface changes made by man over the centuries to prevent landslides or for the construction of important historic buildings. The mineralogical section was dedicated to the building stones. In fact there is in Perugia a very close relationship between some historical periods (etruscan and roman, medieval and the passage between the XIX and XX centuries) and the use of specific lithotypes for the construction of the main religious and civil buildings. Finally the palaeontological section showed for the first time the mammals fossils (Pliocene and Pleistocene) discovered in the past century on the Perugia hill and never visible to the public.

Each section was organized in panels and tools.

The panels were designed following some criteria (Figure 1). The upper section was devoted to the title and to a progressive number showing the path to be followed. At the bottom of the panels only graphic was present for not forcing the visitor to bend down. In the middle part, the text was separated in columns with a logic idea, which impose to the public to read the contents going from the left to the right. On the left only the fundamental concepts were summarized, then moving toward the right side of the panel, other peculiar informations were added. The aim was to introduce the visitor to the topic described on the panel, presenting informations step by step and giving the possibility to decide when to finish reading, without losing important information. Figures and photos were always present. Some supplementary boxes were included for explaining technical words or particular geological concepts (Figure 2).

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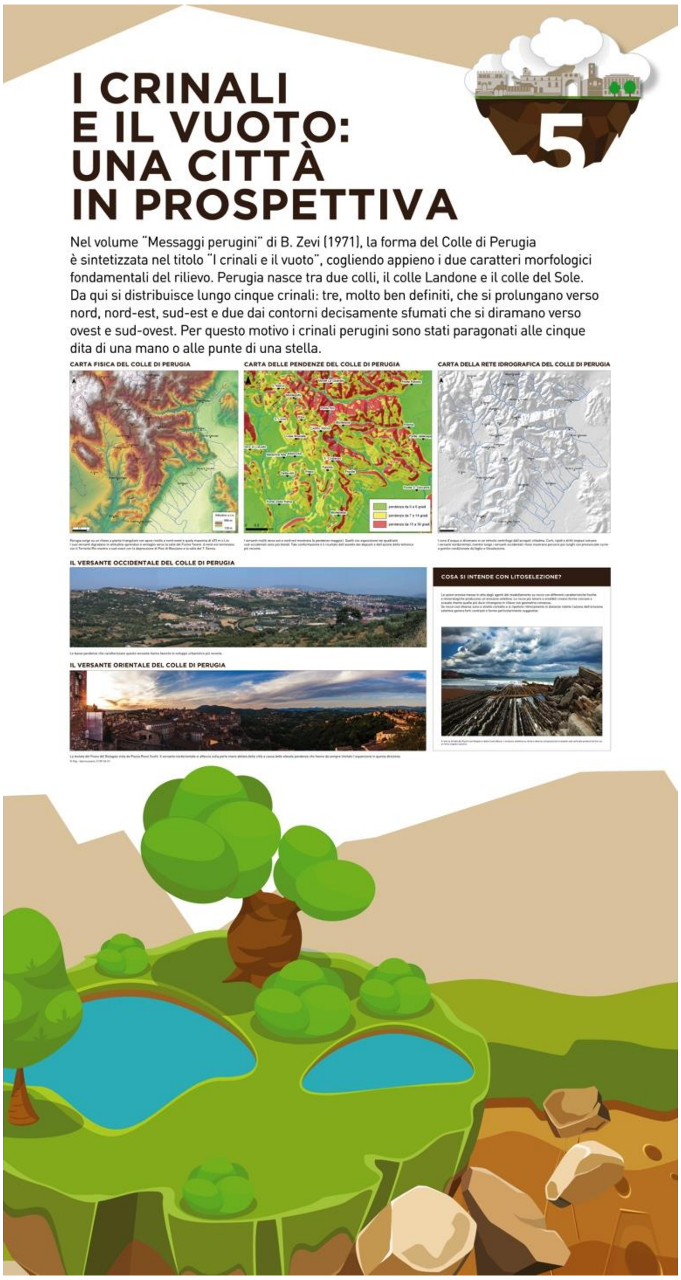

Figure 2. One of the panels in the geomorphological section. It is evident the division of the space and the important role of the graphics.

The monotony of the panels' path was interrupted including some boxes with real rocks. The first three glass boxes contained conglomerates, sand and clay for explaining the idea of the size. In the second one some samples of stones representative for the building stones were presented (Figure 3).

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Figure 3. Panel with the rock samples (on the left) and the video showing the building stones on the most important historical edifices in Perugia (on the right).

In the paleontological section a video was repeated where the fauna and the flora present in the Pliocene and Pleistocene period, in motion thanks to digital reproduction, and some natural environments (lakes, rivers, waterfalls) were overlapped to some of the most representative places in Perugia in order to show the paleogeographic conditions during the last sedimentation phase.

In each section a tool invited the visitors to being an active subject of the exhibition.

For helping the visitor to understand the spatial distribution of the lithotypes a 3D puzzle of the area was created (Figure 4).

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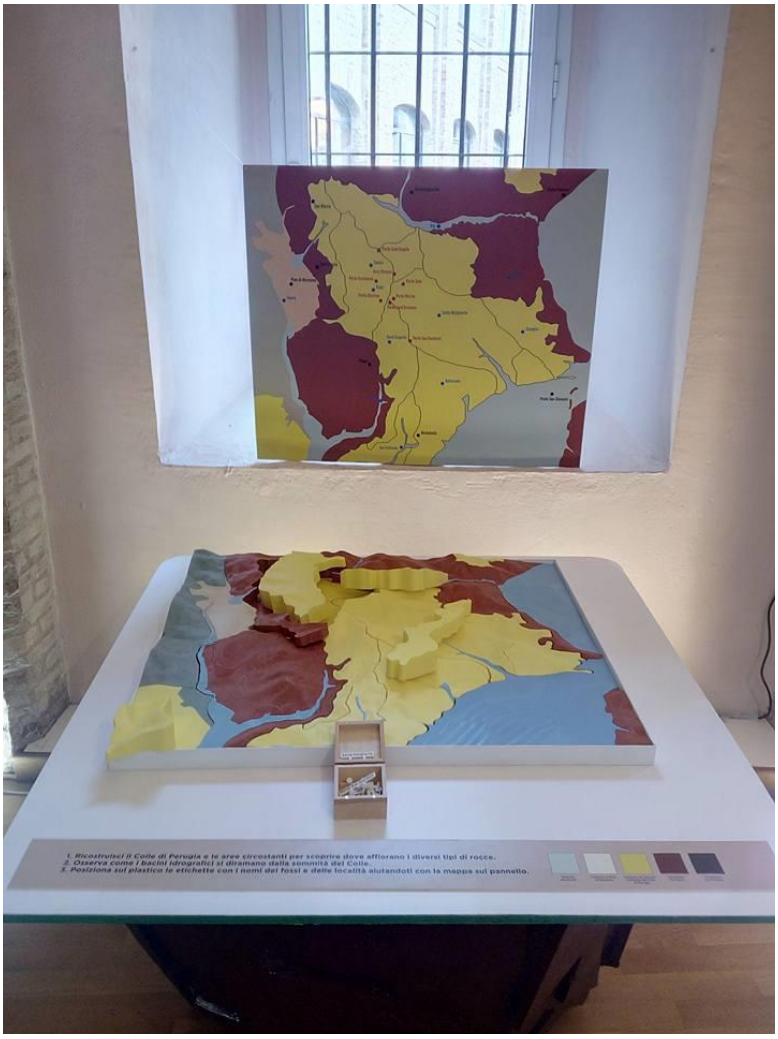

Figure 4. The 3D puzzle in the geological section.

With the support of a 3D printer the Perugia hill and surrounding areas were reproduced cutting some block along the limits between different lithological complexes or along drainage divides. Then some labels were available to be added to the puzzle and to identify the symbolic places of the city.

In the geomorphological section an Augmented Reality (AR) Sandbox was installed (https://arsandbox.ucdavis.edu) allowing the 3D visualization of virtual topographic surfaces. In particular, topographic contour lines and an elevation color map were visualized, and the water flow was simulated. The visitor, by hand-shaping the sand in the box, could modify the topographic surface and try to reproduce the morphology of the area.

In the mineralogical section an optical microscope and thin sections of the main rocks in the exhibition were made available to visitors (Figure 5). Beside the microscope some hand lens were available for observing the macroscopic petrographic characteristics.

Finally, in the palaeontological section, a rhino skull was reproduced with a 3D printer, divided in some pieces along the morphological limits. Visitors were invited to put together the pieces for obtaining the entire skull and better understand the shape and the function of the different pieces (Figure 6).

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Figure 5. The microscope in the mineralogical section.

Figure 6. The palaeontological section with the rhino's skull on the desk.

3.2. Educational workshops for all

During the regular time schedule for museum visits, some laboratories were organized. The laboratories were mainly dedicated to schools. According to the normal school planning Earth Sciences are focused on natural locations. In these laboratories the aim was to introduce the cities as geological environments. Children, teenagers and young people live daily in their cities and most of their educational and recreational experiences are connected to urban infrastructures and places. For this reason is fundamental exploiting what each city can offer to bring young people closer to Earth Sciences. According to the proposed experiences the AR Sandbox appeared to be the most attractive tool. The key for understanding the scientific content is the Augmented Reality. Contour lines and a terrain colour ramp were projected on the virtual topography using a Microsoft Kinect 3D camera.

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Placing an object at a particular height above the sand surface a virtual rain is simulated and water flowed over the landscape. Some fundamental topographic attributes such as slope angle could be visualized and easily modeled and modified. By connecting the slopes to the flow direction and accumulation may facilitate the understanding of drainage network modeling. Moreover AR Sandbox allows to acquiring pictures of the superficial morphology at different times, rebuilding the sequence of events that modify the virtual landscape and offering the opportunity to follow in time the evolution of the landscape. The strong point of this tool is that visitors can interact with the virtual topography by providing the SECRET "SEe and CREaTe" [31] for a good scientific communication.

During the exhibition, weekly workshops were organized for schools of all levels. Moreover, the material presented in the exhibition represented an important resource to be used in the activities of dissemination and information about the degrees in geology offered by the University of Perugia at different schools in the city.

3.3. Urban trekking: inside the museum, outside in the city

Moving outside of the exhibition and remembering the information acquired inside the museum allowed visitors to complete their experience and to consolidate their cultural experience. The idea was to propose trekking tours in four dimensions. Two dimensions were presented walking along a path and referring to a map for improving the sense of direction and spatial arrangement of places. The third dimension was the perspective observable from scenic viewpoints. Being a hilly city Perugia offer several scenographic standpoints. Moreover, Perugia has two opposite landscapes, the steep and uninhabited scenery along the northern area and the gentle and urban one on the opposite side. This contrast is a good starting point for recalling geological and geomorphological aspects as the tectonics, differential erosion and fluvial and gravitational processes.

One of the most successful trekking was from the POST Museum up to the Piazza IV Novembre in the downtown. There were six stops in total: one focused on the fluvial processes and natural phenomena, two on the anthropic modifications of natural morphology, two on building stones, and the last was run underground and exploited the Etruscan Well, one of the most important archaeological evidence of the ancient human presence on the hill related to the water resources research. Trekking experience represents the key for an effective scientific communication. People could see, touch, look for and most of all connect an abstract idea to something tangible. Moreover, they could apply a scientific subject to the daily life and acquire the capability to observe the urban environment from a different perspective. During the trekking tours visitors were entertained above all in the "fossil hunting". None of them, despite having lived in Perugia for decades, had never noticed that on the facade of the city's main church, fossils of ammonites were present (Figure 7). So that the idea of the geologist forced to discover rare and scarce fossils in the natural environment was demolished, suggesting simply to better observing our surroundings, especially historical buildings.

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Figure 7. The palaeontological heritage on the building stones: (**a**) Tthe façade of the San Lorenzo Cathedral the most important church in the Perugia city. The limestone shows two colors, pink and white for a better aesthetic result; (**b**) Some of the tiles in pink color have fossils of ammonites.

4. Final remarks and future perspectives

Looking for the best practice to transfer knowledge from a scientific or technical community to a broader audience in a urban environment, in the 2017 the Department of Physics and Geology in the University of Perugia organized an exhibition. The idea was to open decades of data collected by geologists, archaeologists, historians and architects to citizens and to tourists. The exhibition, differently from seminars or workshops, offers a longer time frame to understand the concepts. Moreover, adding experience as tools, laboratories and urban trekking, people had the opportunity to become an active subject applying the SECRET (SEe and CREaTe) of the scientific communication. The key for the success is a good cooperation between researchers and geologists working in the technical offices of the municipality to select the contents. Then the comparison with the personnel of the museum and their skills to find the optimal compromise between panels and other multimedia tools was also fundamental. Finally, according to our experience, graphic designers represent an essential resource. A scientist is always led to think that his research is appealing and he always tends not to reduce the information to be transmitted to the general public. Graphic designers have the expertise of measuring the proportions between text and figures. A successful panel invites the visitor to continue reading and attracts his attention with a skillful use of graphics. The number of visitors for the "Perugia Upside-down" exhibition was 8.046 people, 3915 of which were students. This was considered as a very good result for the POST Museum.

In this video: https://www.youtube.com/watch?v=oDng-kPKvpw, it is possible to make a virtual tour of the exhibition. The "Perugia Upside-down" paved the road for a growing attention for the Earth Science in Perugia as a promising topic for the geotourism. Presently there are at least two additional projects of geotourism using augmented reality in Perugia developed by the Department of Physics and Geology: HUSH: Hiking in the Urban Scientific Heritage) and HUSH Underground. Mixing science, technology and augmented reality HUSH will show along several urban trekking the naturalistic and geological heritage hidden in the city.

In many historical cities were the initial choice for the location site and the successive actions for urban planning are strictly related to the geological arrangement, geotourism could be a precious resource and a unique opportunity for future researches.

[32].

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