

Article

“Geological Wonders of Italy”: The Coveted Privilege of Disseminating Geology and Geomorphology through Science Documentaries in the Marche Region

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Abstract: This paper proposes an unusual method for the dissemination of geological sciences and the promotion of geotourism: a scientific documentary, where a representative itinerary of geological and geomorphological evolution of the Umbria and Marche regions was presented. The considerations that led to the identification of the geological route proposed to the editorial staff of FOCUS TV are presented in detail. At each stop, there was an explanation by academic professors and researchers, mainly from the Geology Division of the University of Camerino (MC), who explained the outcrops in detail. During the episode, insights were also given into the anthropogenic frequentation of the epigean caves in Frasassi (AN), ancient places of frequentation and worship thanks to their suggestiveness and the sense of magnificence that they can elicit. In addition to the illustration of the individual stops, the article offers further insights into the geomorphology of the most important geosites depicted, all of which are in natural parks or protected areas and characterized by a high landscape value. The result was the production of an episode of the television program ‘Geological Wonders of Italy: the Marche and Umbria Regions’, which was broadcast in October 2022 by the Italian national Mediaset group.

Keywords: geological documentary; geoheritage; geosites; geomorphosites; geotourism; geoeducation; FOCUS TV; Frasassi; Mount Ascensione; Castelluccio plain



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1. Introduction

The state-of-the-art of research provides many communication strategies for the dissemination of geosciences [1]: geological scientific articles, virtual field trips [2], field initiatives [3], geology Olympiads [4], geological hiking [5,6], meetings with scholarships [7], geotourism mobile apps [8–10], cartographies [11], augmented reality [12,13], 3D models [13–16], popular social channels [17,18], the institution of geosites and geoparks [19–21]. The realization of a documentary film is certainly an unusual strategy and an opportunity reserved for only a few people who have had the privilege to collaborate on this type of project. In our case, we felt particularly privileged to have worked with an exceptional colleague, Dr. Luigi Bignami, who recognized the geological significance of our territory.

The documentary [22] represents a fundamental part of this article as Supplementary Material and it follows a series of initiatives carried out over the years by the Geology Division of the University of Camerino to promote the geological heritage of the Marche region, such as conferences, dissemination events, virtual museum activities, field labs, activities for school groups, field trips, didactic geological notebooks, and scientific articles [13]. The physiographic conformation of this region in the central part of Italy is characterized by a western and southern part by the Apennines Mountain ridge with altitudes up to 2500 m above sea level, an eastern coastal area (with beaches and sea cliffs) and an intermediate area that topographically connects the other two (Figure 1). This setting provided the

Marche region with a large variety of landscapes, consisting of mountains, hills, plains and coasts. This geological heritage is an expression of the stratigraphic and structural setting and the geomorphological processes acting above it. The proposal was initially referred only to the Marche region. Later, the Umbria region was included in the production to narrate the evolution of this unique ancient sedimentary basin.

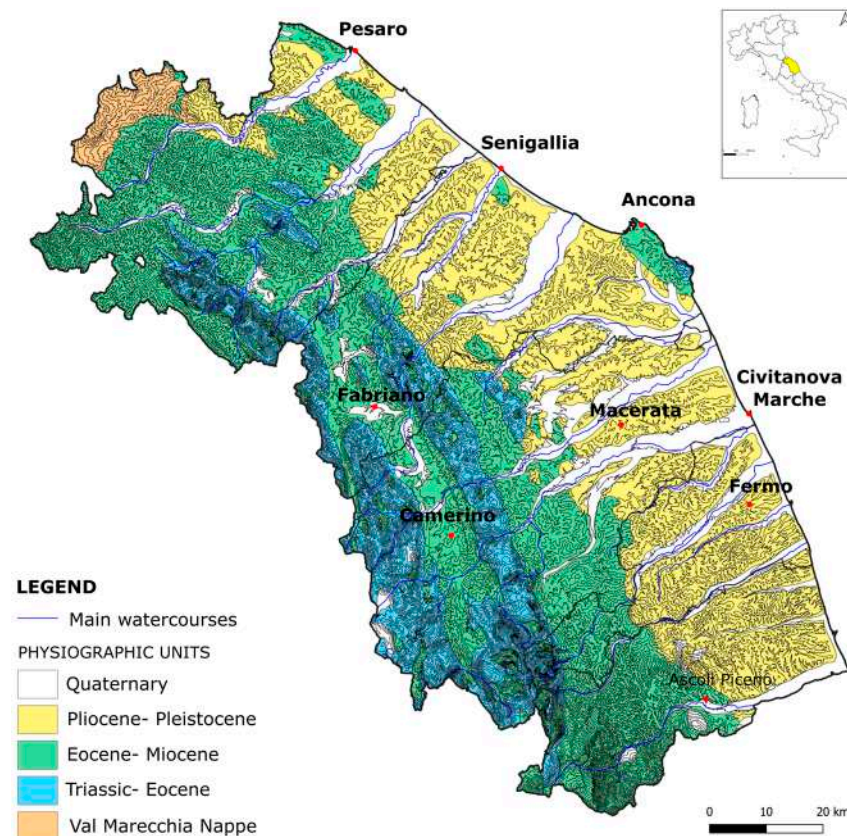


Figure 1. Physiographic setting of the Marche region. Physiographic units were defined based on the geology of the “CARG project” of the Marche Region [23].

The question of understanding and protecting our geological heritage has led to a scientific debate in Europe in recent years, which has provided various indications of methods and criteria for the evaluation of sites of geological interest [24–32] but also various modalities for the popularization of geo-naturalistic heritage [33–36].

The physical qualities of the landscape deserve proper consideration, both for scientific and administrative reasons: geology is part of all natural systems and plays an important role in the study of morphology, climate and biodiversity. Understanding the landscape and communicating its geo-naturalistic value is today a necessity on which the social and economic development of contemporary society is based. It is, therefore, equally important to provide society with knowledge about the geological and geomorphological aspects of the landscape in order to raise awareness of natural hazards and increase resilience to them [37,38].

The themes of the documentary, even if they can sometimes be considered very technical, have been treated by making the language accessible, so that it can be understood by all viewers (of all ages and cultural backgrounds).

The 65 min of the documentary were conceived as an original methodological approach to popularize the geosciences and enhance the geological heritage and the sites of geological and geomorphological interest (hereafter geosites and geomorphological sites) to promote geotourism and, last but not least, to give due importance to the figure of the geologist.

The idea was born from the Geology Division of the University of Camerino (MC), which enterprisingly decided to contact Dr. Luigi Bignami, a geologist and scientific popularizer known in Italy as the presenter of this type of documentary film. Our research team proposed an inter-regional geoitinerary that would summarise the tectonic-stratigraphic evolution of the Marche and Umbria regions which, in the past, constituted a single sedimentary basin formed below sea level.

The episode, whose original Italian title is “Meraviglie geologiche d’Italia: Marche e Umbria”, was not only praised in the scientific community for its educational value, but also represented an important opportunity for the visibility of the territory and the universities involved.

2. Materials and Methods

From a technical point of view, the documentary was recorded in 4k quality, with three different cameras and a quadcopter drone (DJI Mini III).

The first intellectual challenge was to create an itinerary that took into account three fundamental aspects: a high landscape value (for the television attractiveness of the panoramic images), a high representativeness in terms of tectonic-sedimentary and geomorphological evolution of the area (also considering a chronostratigraphic and tectonic order), and finally, a logistical convenience for the television crew (Figure 2) and easy accessibility for the staff who had to transport the technical material.



Figure 2. One of the stops with the crew at work.

Therefore, there was not an evaluation of the scientific quality of the geomorphosites identified as stops in the documentary based on academic classification criteria [25,31,39], although the value of each site is indisputable and, in any case, was selected among the best regional geosites and geomorphosites for emotional impact. The geosites chosen were not selected by taking those with the highest frequentation but by choosing from the most popular and frequented ones. Of course, many geosites were not selected because of similarity and because of television times already defined by the production.

In addition to their high geological value, the sites selected for the in-depth studies (Figure 3) also have a high landscape value, whereby the landscape is considered an expression of the geomorphological landscape. As already mentioned, all stops are located within a natural park (both national and regional) or a protected area.

The narration saw presenter Dr. Luigi Bignami undertake a geo-itinerary through the identified geosites, deepening the aspects of each stop and explaining why that place plays a key role in the geological and geomorphological evolution of the region and, therefore, in the story of the documentary.



Figure 3. Geographical framework with the main stops of the documentary (extract from Google Earth).

In this way, the semiotic value of the media presentation through the format of scientific-naturalistic documentation was added to the landscape–scenic aspect of the selected places. In this way, society will be introduced to the concept of geological and morphological evolution of the territory, but above all to the need to identify measures to protect and enhance geo-natural assets that could disappear either due to climate change or due to anthropogenic effects.

3. Results

The geo-itinerary follows a chrono-stratigraphic order showing rocks, processes, events and morphologies of different geological periods, subdivided and described by defining the most important stages under tectono-stratigraphic and geomorphological evolution.

3.1. The Jurassic Period

The geo-itinerary describes the tectono-stratigraphic history of the Umbria-Marche regions, which in the past were a single underwater basin. The Calcare Massiccio geological Formation was deposited in this area during the Jurassic Period, 200 million years ago. During this period, the basin was involved in an intense synsedimentary tectonic that progressively disarticulated and lowered the area into a horst and graben system composed of structural highs and lows, each one with a particular stratigraphic sequence, different in facies and thickness [40]. The geoenvironment of the Umbria-Marche basin during the Jurassic was of Bahamian type, with a shallow sea level, allowing sunlight to reach the seafloor and, therefore, allowing the proliferation of a wide proliferation of fauna and flora. An ichthyosaur fossil was found in an outcrop in the area [41], which is now preserved in the speleo-archeological museum of San Vittore (Genga, AN, Italy). This hamlet is located just a hundred meters from the Frasassi Gorge (Figure 4), a particularly important geotouristic site hosting the hypogeum complex with the largest cave in Europe, called Abisso Ancona.

Therefore, the site of Frasassi (Genga, AN) was chosen to represent the Jurassic Period, thanks to the outcrops of the Calcare Massiccio Fm. with an excellent stratigraphic continuity and representativeness, in which the tectonic lineaments that fragmented this ancient carbonate platform are very well recognizable.

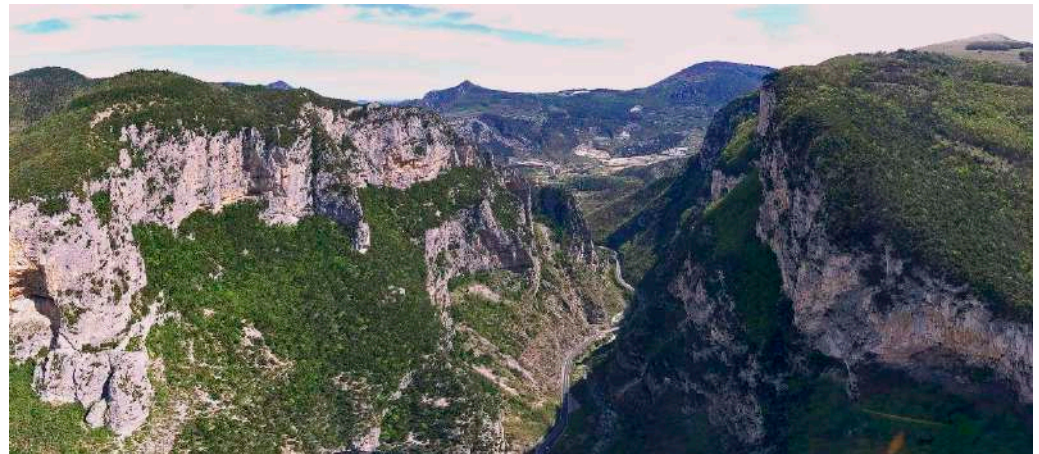


Figure 4. The spectacular landform of the Frasassi Gorge view from the west.

The first stop was located at the top of Mount Revellone, near the hamlet of Castelletta, municipality of Fabriano (AN), at a panoramic point where the above-mentioned physiographic units of the Apennines, the foothill and the coastal region were clearly recognizable. After that, the crew moved to the village of Pierosara in the municipality of Genga (AN), where it was possible to admire a tectonic window on the Jurassic-faulted carbonate platform [42,43]. Another very remarkable stop was the one in Precicchie (Fabriano, AN), where a Jurassic paleo-escarpment with onlap stratification, megabreccias and drapes is very well exposed. Another important stop was the aforementioned museum of San Vittore, a hamlet of Genga (AN). All these places fall within the jurisdiction of the “Gola della Rossa e di Frasassi” Regional Park”. The last stop in the Jurassic is the Calcare Massiccio quarry in Serra San Quirico (AN), cultivated underground. It bears witness to one of the countless applications of geology and geologists in daily and economic life. The very pure limestone (approx. 99.6% of CaCO_3) is used for animal feed, glass production, construction, agriculture and the pharmaceutical industry [44].

3.2. Cretaceous-Paleogene Periods

From the Cretaceous onwards, tectonic stress ended, and sedimentation continued under conditions of relative quietness [45]. An important event during this period was a gigantic asteroid impact on the Earth’s surface that triggered one of the largest mass extinctions on our planet, the effect of which can still be observed today in the Bottaccione Gorge in the Umbria region near the city of Gubbio (PG): in the stratigraphic succession, there is a layer of clay of one-centimetre thickness (interbedded within calcareous rocks) representing 10,000 years of history in which a large quantity of extra-terrestrial material (Iridium) is found but no traces of life are present. This event is very important for determining the chronostratigraphic boundary between the Cretaceous and the Paleogene and is shown in the documentary [46]. Bottaccione Gorge was recently awarded the “Golden Spike” indicating the Golden Stratotype Sections and Points (GSSP) [47] and marking the boundary between Santonian and Campanian (83.6 million years ago).

The Marche region also has its own GSSP [48], which can be seen in the Massignano quarry (municipality of Ancona) and marks the boundary between the Eocene and Oligocene Epochs (39.9 million years ago). This site is located in the Monte Conero Regional Natural Park.

3.3. Miocene-Pliocene Epochs

During the Miocene, the seafloor of the Umbria-Marche basin started to corrugate, in response to a compressive tectonic related to the reversal of the relative movement between the European and African plates. At this time, the first fold and thrust belts began to form and the Apennine Ridge started to migrate from west to east ([45] and references

within). This movement is still active today, leading to compression at the front of the chain (today offshore from the coast of the Adriatic Sea) and crustal extension in the hinterland (today in the Apennines of Umbria and Marche). In the Miocene, the topography of the basin consisted of a series of elevations and depressions extending in a N/NW–S/SE direction. Over time, the most depressed areas became turbiditic foredeep basins, starving for receiving sediments (mostly arenaceous and pelitic flysch) eroded by the chain itself. The largest of these basins is known as the “Laga turbidite basin” and it extends between the Marche and Abruzzo regions. Today’s landscape sees an alternation of sandstone layers remaining prominent, in opposition to layers with a greater pelitic component that are easier to shape. The village of Sala shown in the episode is part of the municipality of Ripatransone (AP) and belongs to the “Gran Sasso and Monti della Laga National Park”.

The next stop relates to gypsum deposits of the “gessoso-solfifera Formation” of the Laga basin, deposited during the Messinian salinity crisis, outcropping in a quarry in the town of San Severino Marche (MC) and well recognizable along its historical walls because of the weathering, which acted by eroding the bricks creating particular grooves.

The uppermost and youngest rocks of the Umbria-Marche stratigraphic succession outcrops are represented by the sediment outcropping in the hamlet of Porchiano (Ascoli Piceno) on the foothill of Mt. Ascensione, which was once an underwater turbiditic foredeep [49].

The area is part of the establishing “Mount Ascension and badlands Park”, where the geomorphological landscape created the unmistakable topographic profile of Mount Ascensione, between the Tronto and Tesino River valleys. The morphological steps present along the profile of the mountain represent depositional alternations of conglomeratic and arenaceous-conglomeratic levels (more resistant lithologies) and arenaceous and arenaceous-pelitic levels (more erodible lithologies) dated Plio-Pleistocene [50,51] (Figure 5). Due to their competence, the coarse-grained deep-water strata remain prominent along the profile with evident selective erosion scarps whose heights can sometimes exceed 80 m. The areas with lower slopes, connecting escarpments, are characterized by a finer grain size and they appear as densely wooded. Along the foothills of Mt. Ascensione, the presence of extended and well-developed badlands-type morphologies is clearly recognizable, set in the pelitic Pliocene Formations, with occasional glacial remnants deposits (represented by sandy-pebbly deposits) of Upper Pleistocene–Holocene stratified and preserved at the top [52,53]. These forms, in addition to representing the dominant landscape element, have also been a conditioning factor of anthropogenic development. In many cases, in fact, the continuous evolution and retrogression of badlands head scarps led to the creation of sharp watershed ridges on which some villages have been isolated, such as the aforementioned Porchiano [54,55]. In this area, erosion processes and tectonic uplift acted with great impetuosity, also thanks to the easily disintegrated terrigenous deposits and relief energy. The geology lecturer in the documentary mentions the widespread gravitational processes in the area, creating road disruptions and the need for continuous restoration interventions. This unstable condition can be considered as the response to the presence of terrigenous lithologies added to an intense structural control (tectonic uplift): these rocks formed about 2.5–3 million years ago at 400–600 m below sea level, and today we find them at 1100 m above sea level. Therefore, in the last 1.5 million years, this area raised 1.5 mm/year, representing the area where the Upper Pliocene bedrock is found at the highest elevations in Europe [54,56].

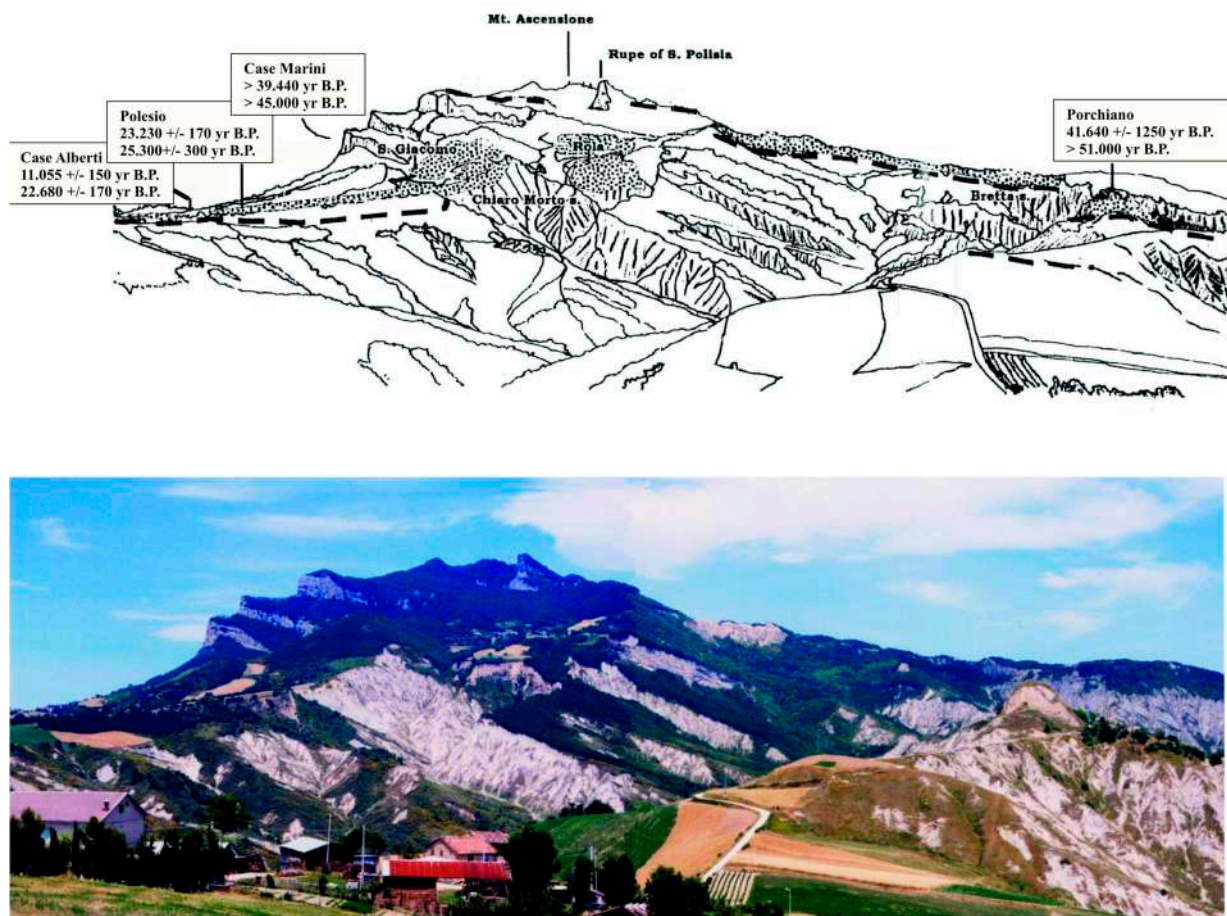


Figure 5. The geomorphological landscape of the southern slope of Mt. Ascensione and the badlands along its slopes ([53] modified).

With this stop, the underwater sedimentation ends. As the compression continued, about 2.5 million years ago, during the Plio-Pleistocene Epoch, the area rose above sea level, and from then on, erosion processes prevailed over depositional processes [57]. This led to the creation of a badlands landscape of immense naturalistic value, where the litho-structural and tectonic controls are clearly and distinctly reflected in the morphology that characterizes the Mt. of Ascension area [55] (Figure 5): the more resistant lithologies of the conglomeratic levels correspond to obvious selective erosion escarpments with heights above 80 m. In correspondence with less resistant lithologies, such as the Pliocene pelites, the morphology is more articulated with a highly hierarchical hydrographic network, which is accompanied by the formation of extensive and well-developed badlands phenomena.

These morphologies are not only the predominant feature of the landscape in this area, but also a determining factor of anthropogenic development: in many cases, the continuous development and retreat of gully heads led to the formation of lean and sharp watershed ridges, on which anthropogenic structures and infrastructures remain isolated [52,53].

3.4. Quaternary Period

One of the first examples of subaerial processes is admirable in Avigliano Umbro (TR), where *Glyptostrobus europaeus* developed in a paleo-lacustrine environment. It is a variety of Cupressaceae extinct today and found as fossilized in this important paleontological site (this is one of the four cases in the world and the only easily accessible and equipped for sightseeing) [58]. The mineralization is not completed but cellulose and lignin are almost perfectly maintained.

Remaining in Umbrian territory, one of the pieces of evidence of active tectonic subsidence is given by the structure of the back basins. The Apenninic territory of the

Umbria-Marche regions is characterized by a series of tectonic valleys alternated with mountain ridges. One of these depressions reached a low topographic elevation that was able to interfere with the local water table level giving rise, precisely, to Lake Trasimeno, a reservoir developed in a tectonic plain [59].

Regarding subsiding plains, it was impossible not to mention the active tectonic of Castelluccio di Norcia plain (PG), which was responsible for the dramatic 2016 earthquakes in the central part of Italy. The expert lecturers illustrated the morphogenesis setting of this tectonic-karst plain, in this way structured as the surface expression of the Mount Vettore–Mount Bove fault system [60,61] and its antithetic lineaments. During scientific studies, geomorphological features of this particular valley have been shown, such as the fault plane and the sinking stream of “fosso dei Mergani”. The western slopes of Cima del Redentore and the same plain show a lot of landforms referable to tectonic, karst, fluvial, gravity, and cryo-nival processes, even if the latter are scarce on this side. From a geomorphological point of view, in this area, it is possible to recognize structural elements, such as fault scarps and triangular facets, a lot of forms and deposits due to running water and glaciation, such as alluvial fans, slope waste deposits, gullies and gully heads, debris/mud rapid flows, glacial cirque escarpments, and the karst forms mainly represented by sinkholes and dolines (Figure 6). The scarce presence of glacial forms is attributable to a recent and very intense tectonic activity whose action erased the Pleistocene glacial forms [60].

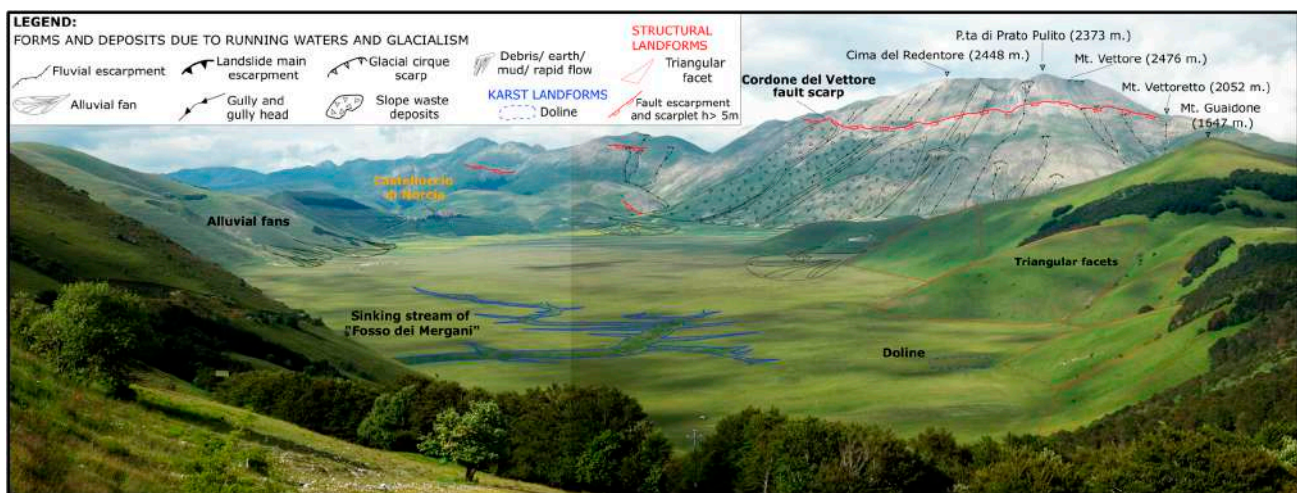


Figure 6. Main representative landforms of Castelluccio di Norcia intermountain basin (redrawn from [60]).

As mentioned before, the migration of the Apennines from west to east is responsible for the compressive tectonics in front of the ridge, which accompanies the thrust, and in response to this migration, a crustal extension in the internal part is active (Apennines area). The Apennines, from a geological point of view, are not exclusively represented by the Umbria-Marche Mountain ridge. In this schematic hinterland–thrust belt–foredeep–foreland system (Figure 7), Apennines are progradating offshore of the Adriatic Sea, East of the promontory of Mount Conero, where it overthrusts under sea level ([62,63] and references within).

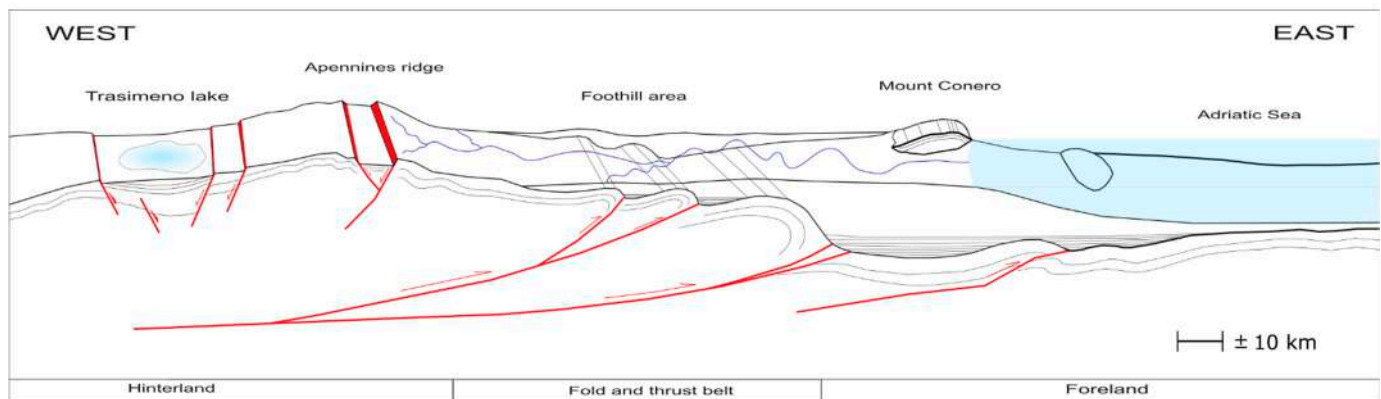


Figure 7. Schematic reconstruction of hinterland-fold and thrust belt–foredeep–foreland system of the Umbria-Marche area (drawn from Farabollini and Bendia).

The external portion of the thrust front is somehow landward represented by the promontory of Mount Conero, whose structure is in outcrop recognizable as a pericline, which just to the east ceases its fold on the hanging wall of the thrust [64].

From a geomorphological point of view, along the Conero seaciff, in addition to the magnificent landscape, many landforms are well recognizable, such as the “scoglio del trave”, the head of a calcarenitic layer that remained prominent due to its degree of cementation (differential erosion), compared to the landslide of Portonovo.

The landslide of Portonovo is probably one of the most educational examples of coastal landslides on the western coast of the Adriatic, where the physiognomic elements (landslide crown, main scarp, displaced material, etc.) are well recognizable (Figure 8). This large gravity-driven mass movement was able to originate two lagunas. In addition to this, the landslide produced a lot of debris causing modifications to the coastline, conditioning the long coast solid transport and, consequently, the dynamics of the shoreline in this section [65,66]. The gravity movement was probably triggered after other previous landslides, in fact, the three-century-old Benedictine Santa Maria in Portonovo Abbey was built on top of an old landslide deposit [67,68].

Another important aspect of the subaerial processes is represented by the karst process, which is very active in the Umbria-Marche area due to the large limestone outcrops. This process created the epigean and hypogean caves. These locations became very frequented places, starting from the Palaeolithic, not only as simple shelters but also as places of worship and burial ([69,70] and references within). One example is given by the “Beata Vergine cave”, along the Frasassi gorge, where geo-archaeological excavations and findings confirmed the presence of ancient human frequentations and today is considered a sacred place thanks to the presence of two Christian structures: a little temple of 1828 and a hermitage of at least 1000 years B.P. (Figure 9) [71]. This location represents today a very important tourist destination thanks to its natural and cultural heritage, which enhances the value of this geomorphosite [72].

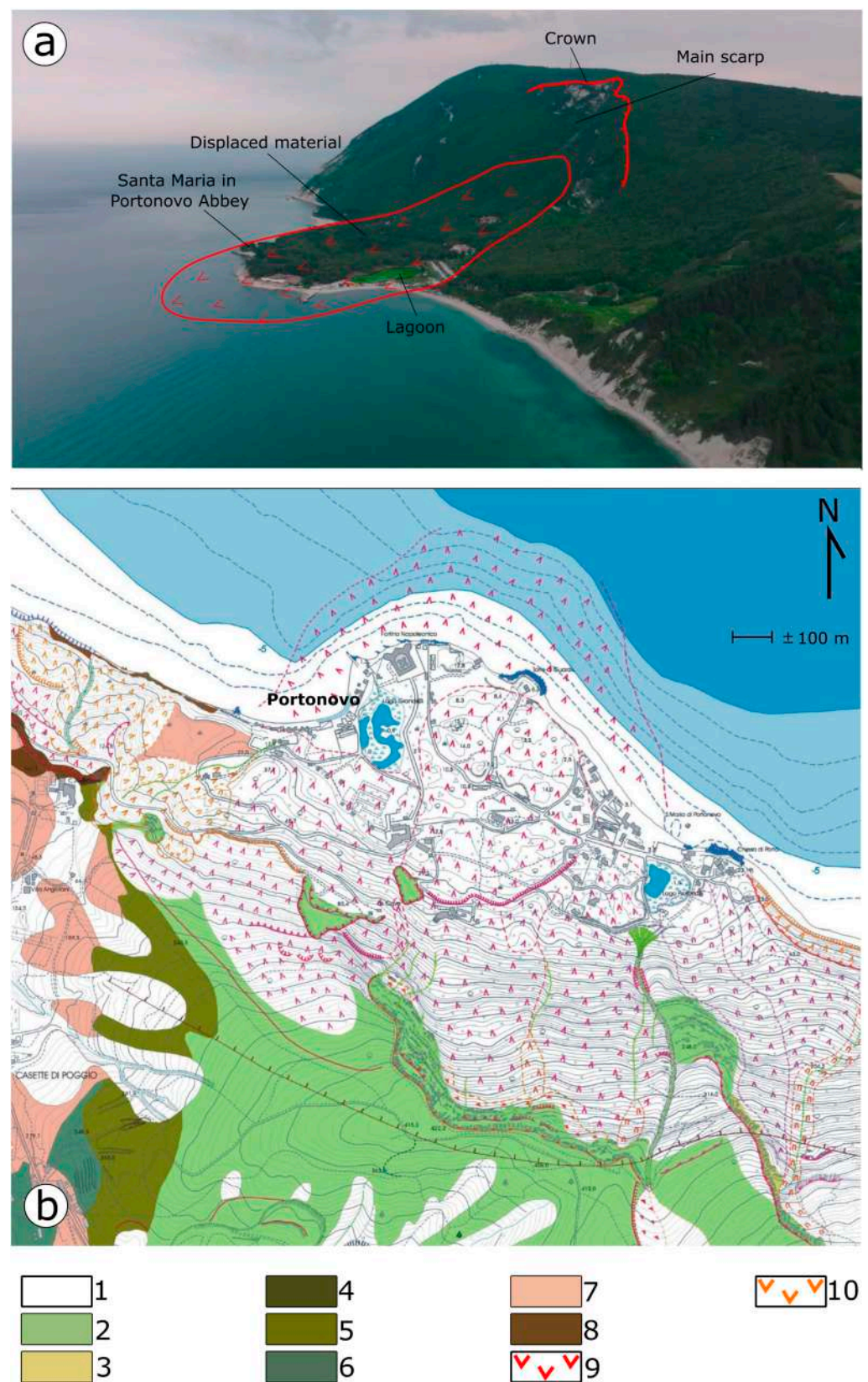


Figure 8. (a) A drawn frame of the documentary with a panoramic view of Portonovo bay, the northern portion of Mount Conero. (b) Geomorphological map of the Portonovo area; (1) slope deposits; (2–8) mainly calcareous and marly calcareous formations; (9) active landslides; (10) dormant landslides (redrawn from [67]).



Figure 9. The thousand-year-old hermitage of “Santa Maria Infra Saxa” on the left and the “Beata Vergine temple” on the right, under the homonymous cave. In the background are the steep limestone walls (Calcare Massiccio) of the Frasassi Gorge.

However, the most important attraction in Frasassi Gorge is represented by the hypogeum complex “Grotta del Fiume–Grotta Grande del Vento”, the so-called Frasassi caves [69].

This documentary allowed us to admire hypogean morphologies thanks to exceptional cave footage captured via drone, yet the underground karst complex of Frasassi is so large and important that it required its own specific treatment.

The last stop considers the youngest rocks of the stratigraphic sequence, which are continental deposits of travertine in a quarry of Acquasanta Terme (AP). Here, along the hydrographic right of the Tronto River, it is possible to find three depositional levels of travertine, placed at different heights with respect to the present valley floor. These sedimentary deposits, well known in the world for mining and usages as “Marmi di Acquasanta” even if they are not marbles, show considerable thicknesses (even hundreds of meters) and areal extensions of several square kilometres.

Their emplacement, so far essentially associated with the emergence from deep fractures of warm waters over-saturated in calcium carbonate (today still present) [73–75], also shows a different deposition in environmental and hydrodynamic key. Travertine deposits testify their deposition in a typically fluvial environment with deep water mixing, due to their arrangement (mostly symmetrical and parallel to the river axis), the presence of typical transport structures and the close relationships with the alluvial deposits present along the riverbed [76]. An important role seems to be played by the sudden and intense climatic changes that occurred during the transition between the glacial and interglacial periods, especially of the middle and upper Pleistocene and in the Holocene, which would have intensely affected the genesis and development of travertines.

4. Discussion and Conclusions

The episode not only focused on geo-heritage resources but also provided some insight into the geological and geomorphological hazards. The mechanics of earthquakes and faulting (compressional and extensional tectonics of Jurassic, Miocene and Quaternary), impact asteroids capable of causing mass extinctions (Bottaccione and Massignano sections) and some examples of landslides (Jurassic megabreccias, olistoliths and the Portonovo landslide) were illustrated and reproduced, also thanks to the 3D video animations created for this purpose and realized under the supervision of the University of Camerino (Figure 10). Sometimes the modelling may not be properly correct, or it may differ slightly from reality

because it has been simplified due to technical limitations or to make the communication easier to understand from a non-expert point of view.

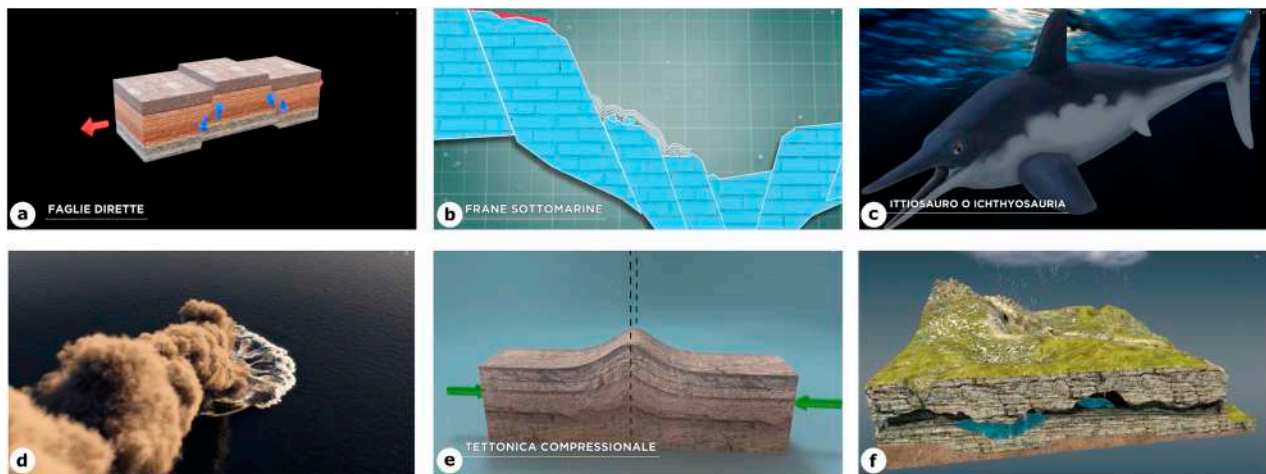


Figure 10. Some of the 3D animations reproduced to make communication easier to understand. (a) Normal faults related to Jurassic tectonics. The red arrows indicate the stretching of the Earth's crust due to distensive tectonics, and the blue arrows indicate the lowering due to the associated normal faults; (b) landslides with olistolites; (c) ichthyosaur; (d) asteroid impact in the Cretaceous; (e) compressive tectonic of Miocene, with the main stress vectors indicated with green lines; (f) external karst and hypogeous environment model.

The episode, broadcast on SKY pay-per-view platform and on the national uncoded channels of “Digitale Terrestre” on FOCUS tv, channel 35, on 20 October 2022, reaching about 1% of share (a value that indicates the percentage ratio between the viewers of a TV channel and the total number of viewers who are watching any other program on the different networks).

This type of divulgation may contribute to making communities aware of the prestige of the geomorphological landscape [77] and of its fragility [78]. Simplification does not mean trivialization and impoverishment but is rather the enrichment of knowledge by enhancing comprehensibility in the context of a wider cultural and ideological debate [79].

This strategy of geological dissemination conducted through the predisposition of scientific documentaries is expected to be a valid method of mass communication because, being broadcast several times on public television and social media, it could be able to reach many recipients. It is easily accessible to the public and, at the same time, it can be considered as an extraordinary and direct example of geoeducation. Each stop shown can be considered as a starting point on which to set up geosites, or geotourism hiking [6], rather than educational lessons aimed at geoeducation, thanks to its language and animations (visual storytelling helps to explain complex ideas) that should make it well received by all recipients.

The share result is certainly to be considered excellent, especially considering that during the evening it was broadcast, there were very important programs, such as soccer matches, fictions and talk shows, which are historically very popular and followed in Italy.

The documentary is continuously broadcast within the speleo-paleontological museum of San Vittore di Genga (AN), near the Frasassi caves, which attracts hundreds of thousands of visitors every year. Furthermore, our research group is planning to distribute it to high schools to bring students closer to the geoheritage of their area and attract enrollment in geology degree programs.

This result undoubtedly means that there is growing attention to scientific and cultural documentaries. The appreciation shown by the geological community and people confirmed the importance of an initiative aimed at consolidating the importance of geology and the dissemination of geological processes in a way that preserves the inestimable value

of the landscape, conceived as a unique expression of the geological and geomorphological heritage.

Supplementary Materials: The documentary episode “Meraviglie geologiche d’Italia: Episode 3: Marche and Umbria” can be viewed on the producer’s website: https://mediasetinfinity.mediaset.it/video/meravigliegeologicheitaliasud/ep-3-marche-e-umbria_F311126401000301 accessed on 19 July 2024.

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