Geotourism around Poggiorsini: unexpected geological elements for a sustainable tourism in internal areas of Murge (Puglia, southern Italy)

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Short Note

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ABSTRACT

The recent candidacy of the Alta Murgia National Park (Puglia, southern Italy) for UNESCO Global Geopark (UGGp) opens several challenges to how to introduce geology along pathways where other topics (biological, archeological, historical, among others) are classically proposed to eco-tourists in the area. This short paper represents the first attempt to show some of the many objetcs that should be deepened to introduce geotourists to the geology of the Murge area. It is addressed to the origin and nature of outcropping rocks, exclusively sedimentary and mainly carbonate in origin. The territory around Poggiorsini village could represent the best place to begin this deepening since it hosts the three main kind of carbonate succession regionally featuring the Murge area and its flanks: Cretaceous rocks recording tropical shallow-water environments; Oligocene rocks recording lacustrine environments; Plio-Pleistocene rocks recording temperate shallow-water environments.

KEY-WORDS: Geotourism, Murge aUGGp, Carbonate Successions, Apulia.

INTRODUCTION

The 2011 Arouca Declaration (https://www.europeangeoparks.org/?p=223) defines geotourism as a form of tourism that "… sustains and enhances the identity of a territory, taking into consideration its geology, environment, culture, aesthetics, heritage and the well-being of its residents. Geological tourism is one of the multiple components of geotourism and is a basic tool for the conservation, dissemination and cherishing of the history of Life on Earth, including its dynamics and mechanisms …".

The recent candidacy for UNESCO Global Geopark (UGGp) of an area extending from Murge and Premurge (Puglia, southern Italy) (Figs 1 and 2), promoted by the Alta Murgia National Park, opens up new opportunities to develop geological researches and to introduce geological issues, generally considered secondary, in the tourist offer (geotourism). Poggiorsini (Fig. 2), the smallest town in the Alta Murgia National Park, could represent either one of the best starting points or one of the intermediate stopping points for geotouristic routes in one of the little known, but geologically interesting, internal areas of Italy. Being halfway between "Castel del Monte" and "Matera", two sites included in the World Heritage List of UNESCO (Fig. 2), Poggiorsini can be a convenient destination for slow tourism when moving from one of these sites to the other.

This study is part of a PhD project aimed at the correct transfer of geological arguments to a non-expert audience. Specifically, this paper is focused on some geological topics that, having in mind the area of Poggiorsini and with a following pedagogic help, could represent some of the contents of the first introductory steps to field activities with schools. This type of approach can also be useful for selecting some geological themes to be included in geotourism proposals.

GEOLOGICAL SETTING: A BRIEF OVERVIEW

To introduce some geological topics in eco-friendly tours, several arguments can be used as a key to understand the crossed territory. The best way to welcome geotourists to a region is to

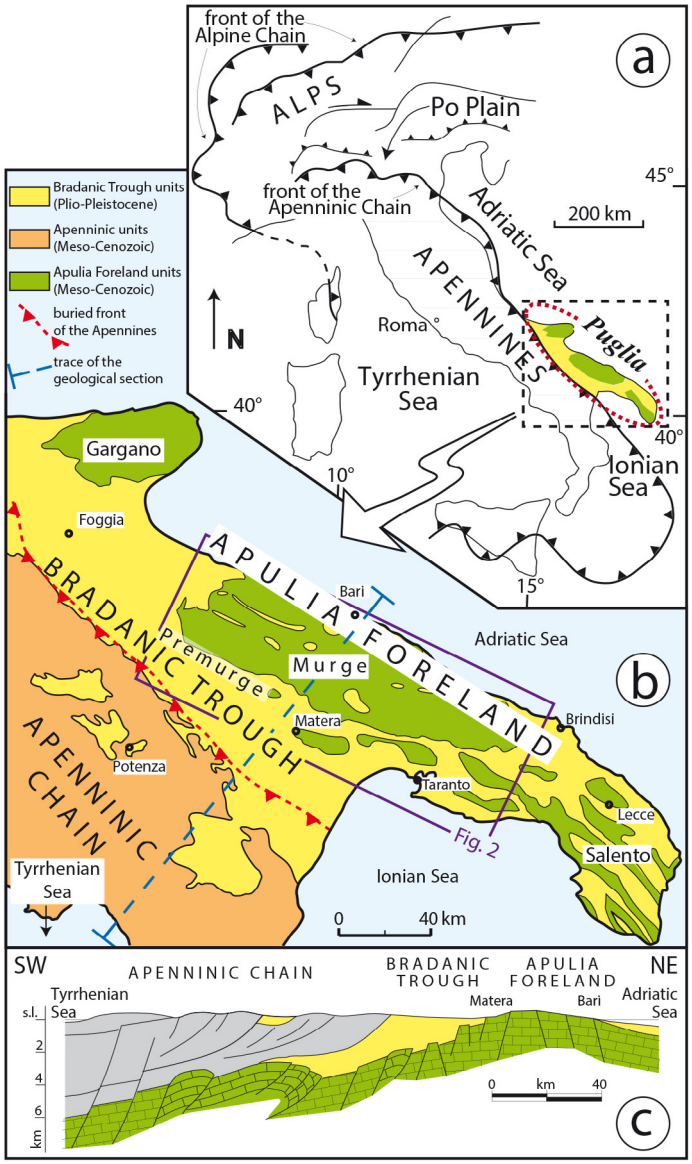

Fig. 1 - a: simplified scheme of orogenic domains along Italy. Note the position of Puglia, representing the foreland (in green) and the foredeep (in yellow) of the Apenninic Chain in southern Italy. After Doglioni (1994), mod.; b and c: schematic geological map and section of southern Italy showing the three orogenic domains featuring the area: the chain (Apennines), the foredeep (Bradanic Trough), and the foreland (Apulia). After Sabato et al. (2019, and quoted references), mod.

provide them a brief overview of the geological setting of the area. In the case of the study area, the "Dipartimento di Scienze della Terra e Geoambientali dell'Università degli Studi di Bari Aldo Moro" (Italy) has found the framework of plate tectonics as the right scenario to place the geological history of the Murge aUGGp (aspiring UNESCO Global Geopark) (Fig. 2) (Tropeano et al., 2023).

According to the plate tectonics theory, a mountain-building process can be observed along the margin of a subducting plate. The Italian peninsula is characterized by the presence of the Apennines, a young and still growing mountain-chain (Fig. 1a). The subducting plate is Adria, which today extends east of the Apennines, and roughly corresponds to the Po Plain, the Adriatic Sea and the Puglia region (Doglioni, 1994). As a whole, these areas represent the foreland and the foredeep for the Apennines, i.e., respectively, the undeformed region and its flexed prosecution toward the chain in an orogenic system (Ricchetti, 1980).

The study area is located in Puglia, at the boundary between Murge and Premurge (Figs 1b and 2), locally representing the foreland and the foredeep respectively. These areas are bounded by a scarp, tens of kilometers in length (Murge Alte scarp) (Fig. 3), corresponding to a main normal fault of a faults system characterizing the whole Murge (Martinis, 1961; Iannone & Pieri, 1982; Festa, 2003). Before the activation of these normal faults, Murge and Premurge were parts of the same region, when the latter was a large intertropical carbonate platform (the Apulia Platform), a slow-subsiding shallow-marine depositional area developed on the Adria Plate (Ricchetti et al., 1988). This history is recorded by a thick outcropping succession of Cretaceous carbonate rocks, whose white blocks were diffusely used to erect the main monumental buildings of Apulia (i.e., Castel del Monte, among many others).

At the end of the Cretaceous, the Apulia Platform became an exposed region mainly subject to karst processes (Pieri, 1980). Due to the Adria Plate flexure, induced by the Apenninic orogeny, during the Miocene the western sector of the old Apulia Platform was again flooded by the sea (Patacca & Scandone, 2013). The flexure reached the area corresponding to the present-day Premurge only during the late Pliocene but the sea did not flood again the area now corresponding to the highest part of Murge (*Alta Murgia* or *Murge Alte* in the Italian terminology) (Tropeano et al. 2002a; 2002b). During the early Pleistocene, the Premurge area represented part of the outer sector of the Apenninic foredeep, the latter konwn as "Bradanic Trough", filled by marine deposits wedging out toward the base of the Murge Alte scarp (Pieri et al. 1996) (Figs 1c, 2 and 3). A severe regional uplift, active since the end of the early Pleistocene (Doglioni et al., 1994; 1996; Cicala et al., 2021), led the drainage network to cut both Murge and Premurge areas. River valleys dissected the lower Pleistocene succession and, reaching the underlying Cretaceous rocks, created small canyons, locally called *gravine.*

GEOTOURISM AROUND POGGIORSINI: A CULTURAL CHALLENGE

Spreading the long history of the Adria Plate is a tough challenge, and this work represents the first attempt to offer arguments to schools for field geotours and classroom geo-insights (cultural/school geotourism). Among the many geological themes that can be introduced crossing the area, we can start by providing the basis for a simple "reading" of three ancient and different outcropping carbonate successions, each of them linked to different palaeoenvironments: the Cretaceous intertropical platform succession, the Oligocene lacustrine succession, the lower Pleistocene temperate-sea succession.

The Cretaceous intertropical platform succession

The Cretaceous carbonate succession of Murge derives from the aggradation (i.e., the overlapping of sediments over time) in shallow marine environments and the subsequent

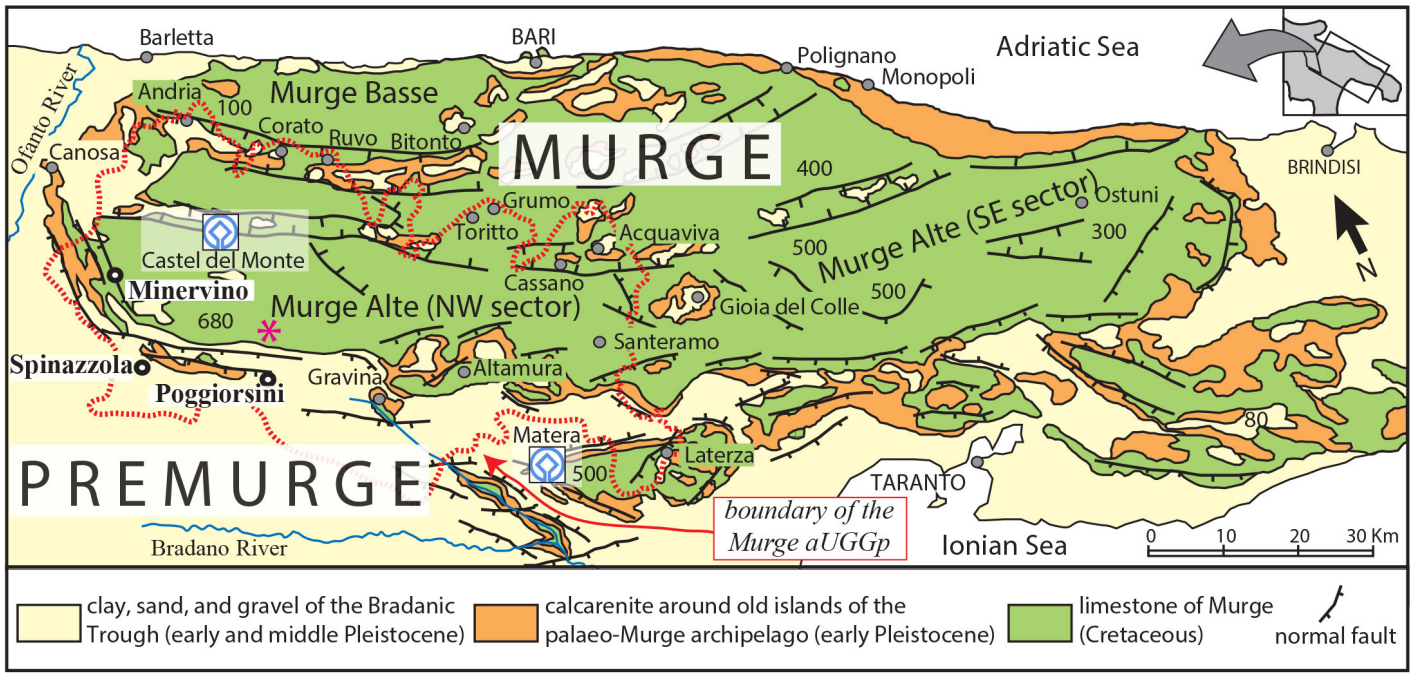

Fig. 2 - Structural sketch of the Murge area (see Fig. 1b for the location). Poggiorsini, Spinazzola and Minervino are the three municipalities considered internal areas of Murge (PhD theme). The asterisk shows the position of the Oligocene lacustrine succession along the Alte Murge scarp, North of Poggiorsini. Note the location of the two UNESCO World Heritage sites (Castel del Monte and Matera) quoted in the text. The approximate boundary of the Murge aspiring UNESCO Global Geopark (Murge aUGGp) is reported. After Pieri et al. (1997), mod.

lithification of mainly fine-grained particles whose accumulation built up the Apulia Carbonate Platform (D'Argenio, 1974; Ricchetti, 1975). During the Cretaceous, the Earth was a different world from the one we live in today ("icehouse world"); the most important differences are globally related to a warmer climate, which led to the absence of polar ice caps ("greenhouse world"), to an impressive different distribution of lands and seas (palaeogeography), to a very different biological community developed up to that time (Skelton, 2003). Focusing exclusively on the latter topic and taking into consideration only the fauna, two examples can be used to introduce teenage students to the Cretaceous world recorded in the Murge area. The first example is that of the rudists, which were the most common marine bivalves, also in the study area (Laviano et al., 1998a), and which became worldwide extinct at the end of the Cretaceous (Seilacher, 1998). Their evolution led rudists to live semi-embedded or attached to the seabed, mainly in shallow-marine environments, and to have two very asymmetric valves: a large, conical-shaped one, and a smaller, lid-like or coiled one (Cestari & Sartorio, 1995). The evolution of rudist groups in shallow-water domains during the Cretaceous reflects major climatic changes occurred at a global scale typically marked by the deposition of black shales in deep-water environments (OAE - Oceanic Anoxic Events *sensu* Schlanger & Jenkyns, 1976) and by the coeval mass extinction of biota such as recumbent rudists (i.e., not all the rudists species) (Skelton, 2003). This latter extinction event is well-recorded in the Murge where the last-living caprinid rudists occur in upper Cenomanian limestones exposed between Poggiorsini and Ruvo localities (Laviano et al., 1998b). The record of the same OAE in a deep-water succession is located in the close southern Apennines and has been proposed as a geotouristic destination by Gallicchio & Sabato (2011).

The second example is that of dinosaurs; during cyclic sea-level drops linked to eustacy, the previous marine environments became emerged muddy flat-regions (Spalluto 2008; 2012), sometimes crossed by dinosaurs, as recorded in the Murge area exclusively by several surfaces with tetrapod tracks (i.e., the Altamura surface at the bottom of the Pontrelli quarry - Nicosia et al., 2000; Petti et al., 2022). The diffuse presence of dinosaurs tracks in the Murge area (Petruzzelli et al., 2019; Petti et al., 2020) suggests the existence of a continental bridge between Adria and other plates during Cretaceous (Zarcone et al., 2010).

A major long-lasting exposure of the Apulia Carbonate Platform during the Cretaceous led to the development of bauxites, now characterizing the Murgetta Rossa area in the vicinity of Spinazzola; because the presence of these residual rocks, two carbonate units were distinguished in the Cretaceous succession of Murge: the Calcare di Bari Fm, below the bauxites, and the Calcare di Altamura Fm, above them (Valduga, 1965).

Due to the great temporal distance between the Cretaceous Apulia Carbonate Platform and a modern "analogous" region (e.g., the Bahamas, according to Eberli et al., 2004), introducing geological arguments to a wide auditorium represents a hard challenge. How to explain: i) the presence of marine and terrestrial, today extinct, animals in the same environments, ii) the regional size and the intertropical location of the old region (the Apulia Carbonate Platform), a small part of which will become the Cretaceous succession of Murge, iii) the original landscape in which those animals were living?

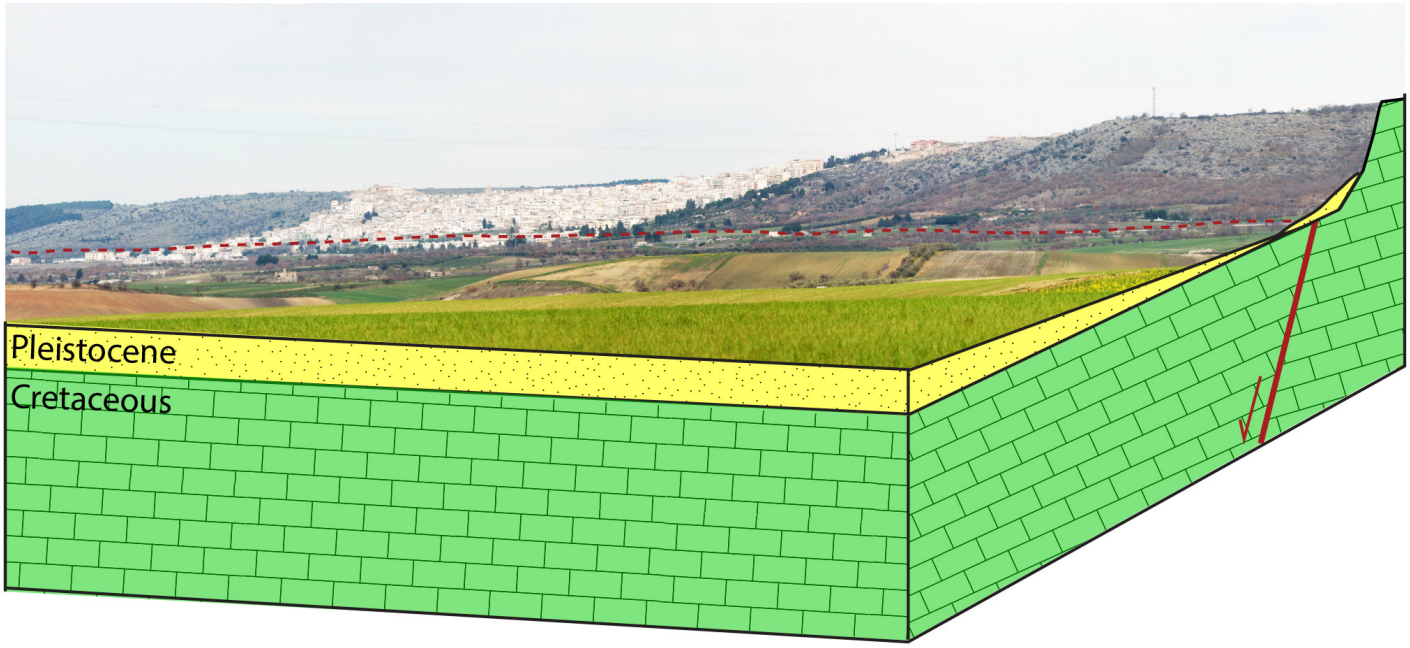

Fig. 3 - The Murge Alte scarp along which Minervino village was built. The 3D sketch shows the approximate position of the main fault from which the scarp originated.

The Oligocene lacustrine succession

A small calcareous lacustrine succession, the Calcare a Planorbis Fm (Azzaroli et al.,1968) (see the asterisk North of Poggiorsini in Fig. 2), crops out along the Murge Alte scarp in the vicinity of Poggiorsini and lies unconformably on Cretaceous limestones (Fig. 4). The succession consists of an up to 35 m thick well-stratified carbonates characterized by a fossiliferous association comprising freshwater molluscs, among which Gastropods (Lymnaea and Planorbis, typical forms of continental lake environments) and Ostracods abound, accompanied by Characeae and Cyanophyceae. This fossils content suggests an age spanning between the early Oligocene and the early Miocene (Iannone, 1996). Moreover, an Oligocene age is congruent with the age attributed to similar deposits in other settings of the Apulia Foreland (e.g., Esu et al., 1994).

Apart from palaeoenvironmental and paleontological considerations, an intriguing topic, difficult to popularize, regards the relationships between tectonics and sedimentation referred to the development of the lacustrine succession and to its present-day location; that is, a lacustrine deposit perched at the top of the scarp, i.e., onto the receded plain of a Quaternary fault. As observed by Iannone (1996), the lacustrine succession comprises two partly overlapping lenticular bodies (Fig. 4). This configuration suggests that the lacustrine succession developed at least in two phases on a depression whose depocenter changed (moved laterally) during the sedimentation of the two lenticular bodies. Commonly, this stratigraphic architecture is induced by a transtensional faults system (Wu et al., 2009), that is a system where faults move obliquely with respect to each other. An area located in the close southern Apennines, where a similar transcurrent phenomenon is recorded by Quaternary lacustrine deposits (Onofrio et al., 2009), has been proposed as a geotouristic destination (Tropeano et al., 2011; Sabato et al., 2019). A twinning between the two lacustrine successions could be proposed and this could be one of the future goals of the PhD project.

The lower Pleistocene temperate-sea succession

During the early Pleistocene, the flexure of the Cretaceous succession toward the Apennines favored the return of the sea onto the carbonate rocks, exposed since the end of the Cretaceous, in the area today corresponding to the Premurge (Pieri, 1980)

Fig. 4 - The Oligocene lacustrine succession perched at the top of the Murge Alte scarp.

(Figs 1 and 2). The first phase of submersion was characterized by shallow-marine environments with sedimentation of carbonate particles made up almost exclusively of coarse-grained (sand- and gravel-sized) bioclasts (Iannone & Pieri, 1979). The fossil remains mainly belong to echinoids, brachiopods, bivalves, gastropods, bryozoans, benthic and rare planktonic foraminifera; their assemblage indicates temperate marine palaeoenvironments (Tropeano & Sabato, 2000). These deposits will become the Calcarenite di Gravina Fm, a carbonate succession very different from the Cretaceous one and well-known in the area for being the soft-rock dug to "create" some rupestrian old towns, such as the famous "Sassi di Matera" (Tropeano et al., 2018; Sabato et al., 2019) (Fig. 5).

An interesting exercise is to compare these rocks with their present-day still not lithified counterparts, represented by carbonate sediments featuring coastal settings of the Tremiti archipelago and the Salento coast in Puglia (Italy) (Tropeano & Spalluto, 2006). Since these present-day sediments, mainly made up of "skeletal" (hard) fragments, come from the biological community living in those seas, they can be easily compared with the bioclasts that characterize the rocks of the Calcarenite di Gravina Fm (see examples in: Tropeano et al., 2022).

CONCLUDING REMARKS

In order to propose geological topics in sustainable tours (i.e., geoturism) and to connect geology, environment, and cultural-historical heritage, the first challenge is to try to link the present-day landscape to the "anatomy" of the crossed region. By the term anatomy we intend to explain: i) the nature and origin of outcropping rocks, ii) the long geological history which led these rocks to assume their present-day attitude, and iii) the geomorphological processes which, being also influenced by both nature and attitude of rocks, led to the landscape development, with the contribute of the evolving biological community and with the more recent anthropogenic footprint.

Speaking exclusively about nature and origin of outcropping rocks, this short paper represents the first attempt to show which topics should be deepened to introduce geotourists to the anatomy of the Murge area, whose outcropping rocks are exclusively sedimentary and mainly carbonate in origin. The territory around Poggiorsini village could represent the best place to begin this deepening since it hosts the three main kind of carbonate succession regionally featuring the Murge area and its flanks: Cretaceous rocks recording tropical shallow-water environments; Oligocene rocks recording lacustrine environments; Plio-Pleistocene rocks recording temperate shallow-water environments. The proposed challenge is how to compare palaeoenvironments recorded in the rocks with present-day analogous environments in the world, and how to "reveal" the long geo-history hidden in the present-day landscape.

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Fig. 5 - The stratigraphic contact (unconformity) between Cretaceous limestones and Pleistocene carbonates of the Calcarenite di Gravina Fm. Note the presence of anthropic caves at the base of the easy digging Pleistocene carbonates.

di percorsi natura di carattere didattico/geoturistico nell'ambito del candidato Geoparco delle Murge (aUGGp): la stratigrafia delle successioni carbonatiche affioranti nei comuni delle aree interne delle Murge (Poggiorsini, Spinazzola e Minervino Murge) come base di divulgazione geo-scientifica" ["Study of didactic/geotouristic nature-trails in the context of the candidate Geopark of Murge (aUGGp): the stratigraphy of the carbonate successions outcropping in the municipalities of the internal areas of Murge (Poggiorsini, Spinazzola and Minervino Murge) as a basis for geo-scientific dissemination"] aimed at the correct transfer of geological topics to a non-expert audience. PhD Grant was funded by the "Agenzia per lo Sviluppo Territoriale" ("D.M. 725, 22-06-2021 - Dottorato Comunale") to the Bari University through the "Area Interna Alta Murgia" (Municipalities of Minervino Murge, Poggiorsini Spinazzola).
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