

The Geological and Palaeontological Heritage of the Buzău Land Geopark (Carpathians, Romania)

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Abstract The Buzău Land Geopark, located in SE Romania, in the outer part of the Eastern Carpathians, encloses many geological and palaeontological sites of high scientific value, including unique geological phenomena. The amber deposits, the salt caves, the mud volcanoes, the mineral springs and the Neogene fossiliferous sites, along with the impressive beautiful geological landforms and landscapes represent a significant geoheritage and an attraction for worldwide tourists. The geological and palaeontological heritage of The Buzău Land Geopark may be seen also as a strong supporter for Earth Science education, and one of the best policies to promote geoconservation. So far, however, only a few geological and palaeontological sites are protected; for the other sites, the significant geodiversity indicates that they have a good potential to become protected areas of national interest. The future actions that will be taken as results of the researches in The Buzău Land Geopark need to support geoconservation, leading also to the development of the entire region.

Key Words Mud volcanoes · Mineral springs · Amber · Neogene fossil sites · Eastern Carpathians

Introduction

The territory of Romania displays rich and complex geological features, covering more than 500 million years of Earth history. An important segment of the Carpathian mountain belt,

including the Eastern Carpathians, the Southern Carpathians and the Apuseni Mountains, bordered by platforms in the outer part, and by the Transylvanian Basin in the inner part, occur in various Romanian regions. Therefore, from the Palaeozoic up to the Present, a wide record of the marine, brackish and continental sedimentation is exposed.

Despite the geological richness, including many representative sites, the only Romanian geopark included so far in the European Geopark Network and UNESCO Global Geoparks is represented by ‘The Hațeg Country Dinosaur Geopark’. It is situated at the western end of the Southern Carpathians, containing, as the main geological and palaeontological values dinosaur-bearing deposits of Upper Cretaceous in age, with representatives of all major vertebrate groups from fishes to mammals (Grigorescu et al. 1985; Buffeteau et al. 2004; Grigorescu 2010; Csiki et al. 2010).

Another area that contains a significant geological and palaeontological heritage, and hence a great potential for the geotourism is situated in Buzău County, in the southern part of the Eastern Carpathians (Fig. 1). The Buzău Land Geopark (BLG) project started as an initiative of the University of Bucharest in partnership with the Buzău County Council and has been supported by other local and national bodies and institutions (Andrășanu 2010; Andrășanu et al. 2015).

This initiative has produced several national projects dealing with public awareness, cultural events, promotion, and informal education. Recently, these ideas have been organized into a successful international applied research project funded by the EEA Financial Mechanism, led by the Institute of Geodynamics of the Romanian Academy, having as Romanian partners the University of Bucharest (Faculty of Geology and Geophysics), National Institute of Marine Geology and Geo-ecology, the National Museum of the Romanian Peasant, as well as the University Babeș-Bolyai from Cluj-Napoca. The project benefits from a strong

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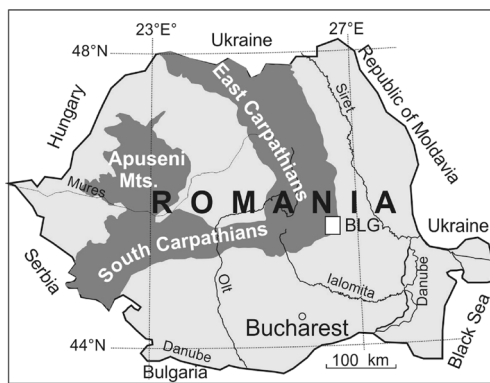


Fig. 1 Location of the Buzău Land Geopark (BLG) at the southern end of the Eastern Carpathians (Romania)

financial support from Norway, including significant scientific contributions from the project partners such as Telemarkforskning, the Norwegian University of Life Science (NMBU) and Gea Norvegica Geopark.

The main purpose of this paper is to highlight the geological and palaeontological heritage of the BLG, including existing geosites, along with other important geological and palaeontological sites which are not yet protected. A detailed knowledge of the whole geoheritage will greatly help the Buzău Land UNESCO Geopark initiative.

Geological Context of the Buzău Land Geopark

The geology of the territory of the Buzău Land Geopark (BLG), placed in the southern part of the Eastern Carpathians, is quite complicate, and shows Alpine tectonics, characterized by nappe system structures. The nappes were involved in two main tectonic phases (Săndulescu 1984, 1995), within the Late Cretaceous (Laramian tectonic movement) and Early Miocene (Burdigalian). All the nappes that occur in the area of BLG belong to the Outer Moldavides, including the Tarcău Nappe (towards the west) and the Subcarpathian Nappe (towards the east). In the eastern extremity of the BLG, deposits of the foredeep also occur (Fig. 2).

The territory of the BLG exposes successions of Late Cretaceous, Palaeogene, Miocene, Pliocene and Pleistocene age. The Upper Cretaceous hemipelagic sediments (variegated clays and marls) and calcareous turbidites are followed by the Palaeocene and Eocene turbidites, dominated by thick arenites and Oligocene bituminous rocks, such as marlstones, shales, and sandstones (Teisseyre 1897; Motaș et al. 1967; Dumitrescu et al. 1968; Ștefănescu et al., 1989; Melinte 2005).

The Oligocene sediments of this area, as in the whole outer part of the Eastern Carpathian region, represent important source and reservoir rocks for hydrocarbons. This character has been known since the middle part of the nineteenth

Century (Coquand 1867), and many oil and gas sites are still producing. The base of the Miocene is characterized by the occurrence of salt diapirs.

From the base of Miocene, thick turbidities and molasse deposits started to accumulate. The Lower Miocene marine paleoenvironment progressively shifted to a brackish setting within the Middle Miocene, while from the Lower Pliocene a fluvial-lacustrine environment was established (Jipa and Olariu 2013).

Palaeogeographically, up to the Middle Palaeogene (Eocene), the BLG territory, like the entire Eastern Carpathians, was part of the Tethyan Domain. Starting from the base of the Oligocene, when the Paratethyan Realm was first isolated from the Tethys, the area was part of the Central Paratethys. Since the Middle Miocene, when the Paratethys divided in smaller basins with restricted circulation, the Eastern Carpathian territory, including the BLG, became part of the Eastern Paratethyan Realm (Neveskaia et al. 1986; Rögl 1998; Piller et al. 2007).

The Buzău Amber

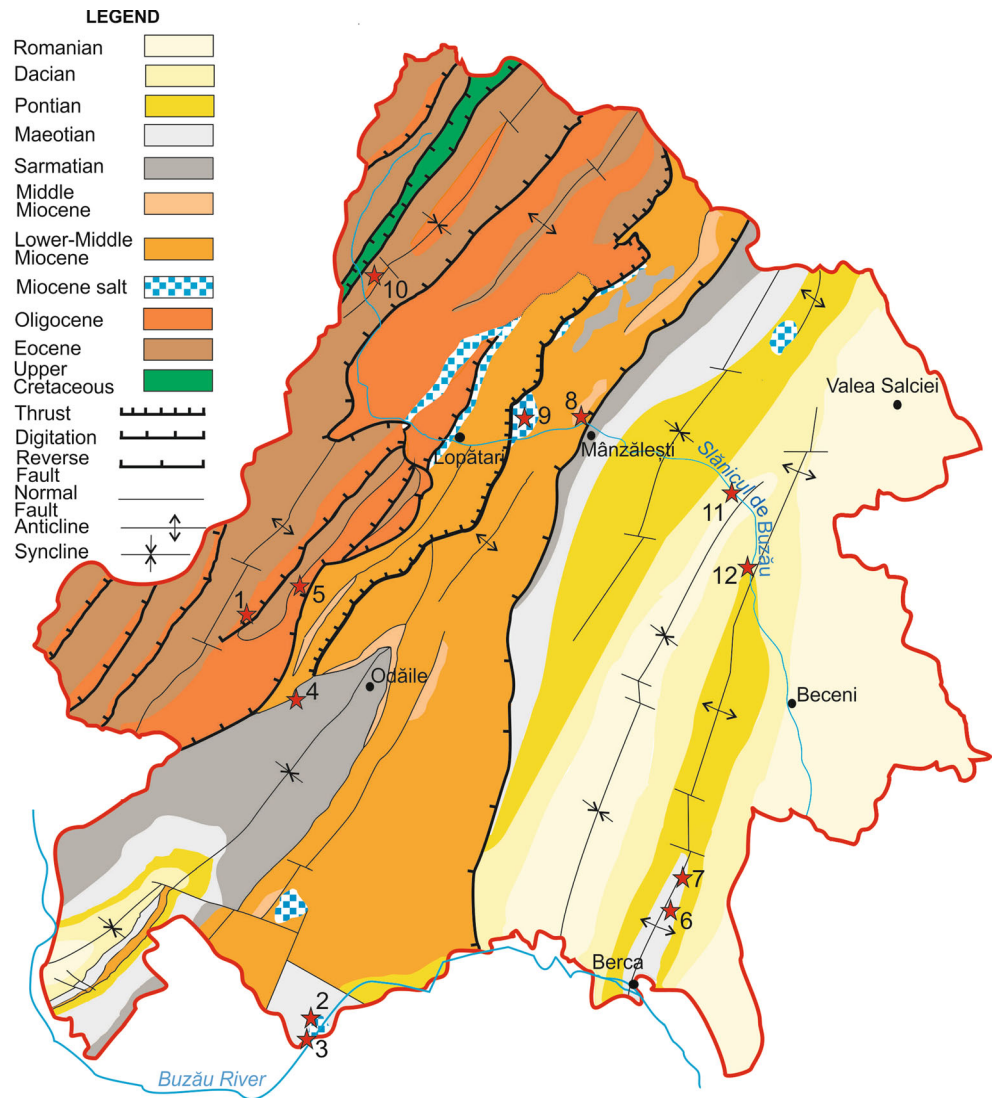
A significant site of the BLG is ‘The Buzău Amber’ that corresponds to the IUCN category III (geological and paleontological natural reserve), located in the Colți village, at an altitude of 600 m. The Buzău Amber, declared protected area in 2000, with a surface of 2.52 ha, corresponds only to the richest amber site in the area, i.e. Strâmba – Comarnici, one of a total of seven in the region.

The amber occurs, in the perimeter of BLG, in the Kliwa Bituminous facies belonging to the Tarcău Nappe. The rock successions are composed of argillaceous shales (dysodilic shales), bituminous cherts (menilites), bituminous marlstones and quartzitic sandstones (Fig. 3A). The age of these sediments extends from the Early Oligocene (Rupelian) up to the Early Miocene (Burdigalian) (Melinte 2005).

The amber from the BLG territory was firstly documented in 1578 (Ghiurcă, 1999) and described, at the end of the nineteenth Century, as Rumanit (Helm 1891). The latter author made a distinction, based on physical and chemical features, between the BLG and amber, as ‘Succinite’. At the beginning of the twentieth Century, the mines from the area of BLG were some of the most productive in Europe.

The Buzău Amber shows a dominantly yellow colour, which may vary from red to black, with over 160 shades. Fossilized arachnids, beetles, diptera, crustaceans, millipedes, hymenoptera, lepidoptera, reptiles, bird feathers and animal hair have been preserved in the amber (Protescu 1937; Frunzescu and Brănoiu 2004). In the BLG territory, palaeobotanical investigations on the sediment containing amber shows the presence of fossil wood, such as *Sequoioxylon*

Fig. 2 The geology of the Buzău Land Geopark (modified and simplified after Motaş et al. 1967; Dumitrescu et al. 1968; Ştefănescu et al. 1993). Geological and palaeontological sites: 1 – The Buzău Amber; 2 – The Buzău’s Salt; 3 – The Limestone Blocks from Bădila; 4 – Babele (Old Ladies) from Ulmet; 5 – The Mineral Springs from Fişici; 6 – Pâcelele Mici (The Small Mud Volcanoes from Berca); 7 – Pâcelele Mari (The Big Mud Volcanoes from Berca); 8 – The White Stone ‘La Grunj’; 9 – The Meledic Plateau; 10 – The Everlasting Fires; 11 – Stratotype of the Romanian stage; 12 – Stratotype of the Dacian stage



gypsaceum, *Laurixylon murgoci* and *Icacinoxylon* sp. (Petrescu et al. 1989; Iamandei et al. 2012).

The cited authors indicate that the Oligocene-Lower Miocene deposits are characterized by two palynological associations: one dominated by conifers (40–52 %) and another, mainly composed of angiosperms (45–55 %). This palaeobotanical data indicates the existence of extensive coniferous forests in the BLG area about 25 million years ago, similar to the modern forests of the region, mixed with subtropical taxa such as *Sequoia*. Most probably, the widespread Paleogene conifers represent the main source of the ancient resin that fossilized into the amber presently occurring in the BLG area.

The Buzău’s Salt

This site, located at the western end of the Bădila village, in the SW part of the BLG (Fig. 2), was included in the list of

natural monuments in Romania from 1955; it covers 1.77 ha and was declared a geological and botanical protected area in 2000 (through approval of the National Landscaping - Section III - Protected Areas).

The natural reserve includes salt springs and salt efflorescences (Fig. 4A), related to the existence of an underground Lower Miocene salt dome. In terms of the floras, halophile species, such as the sea buckthorn (*Hippophae rhamnoides*) and herbaceous species (*Puccinellia distans*), plants adapted to salty soils, grow at this site (Fig. 4B). The highly saline salt springs are still used by local people to preserve the food.

The Limestone Blocks from Bădila

This site, spread on 3.02 ha, is also situated nearby the Bădila village, close to the Buzău’s Salt Natural Reserve, approximately 500 m to the west. The Limestone Blocks from Bădila were included in a Geological and Palaeontological Nature



Fig. 3 The Buzău Amber geological and palaeontological protected site. **a** The Oligocene sediments containing amber ('Rumanit') in the Colți village. **b** The Museum of the Amber located in the Colți village

Reserve, corresponding to the IUCN category III, being declared a protected area in 2000. The geological site consists of tens of rocky blocks, up to 15 m in height (Fig. 5A), displaying different sizes and shapes; their size varies from 1 m³ to 400 m³ and probably the whole limestone mass reaches a volume of around 10,000 m³.

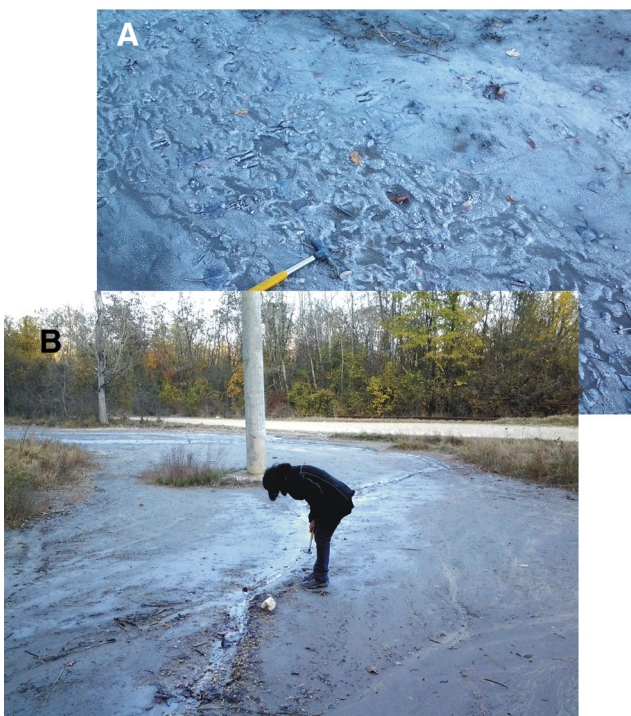


Fig. 4 **a** Salt springs in the protected area The Buzău's Salt. **b** The protected area The Buzău's Salt and its halophile vegetation

The blocks are Upper Jurassic limestones; some of them enclose conglomerates with a limy matrix and various elements, such as Mesozoic reef limestones, and Palaeogene sedimentary rocks. Tectonically, the southern extremity of the BLG, where the site is located, belongs to the folded Inner Foredeep of the Eastern Carpathians (Motaș et al. 1967). The Limestone Blocks from Bădila represent an unusual occurrence, as they are located in an area where no massive limestones crop out. Moreover, the Upper Jurassic limestones have a different age to the surrounding area, where the deposits are represented by Miocene salt breccia.

Possibly, the occurrence of Jurassic limestones is linked to salt diapirism which is widespread in the southern part of the Eastern Carpathians. It can be assumed that Jurassic limestones, known to occur in the Moesian Platform that extends beneath the southern Eastern Carpathians, were affected by the Lower Miocene tectonic phase, being afterwards involved in salt diapirism.

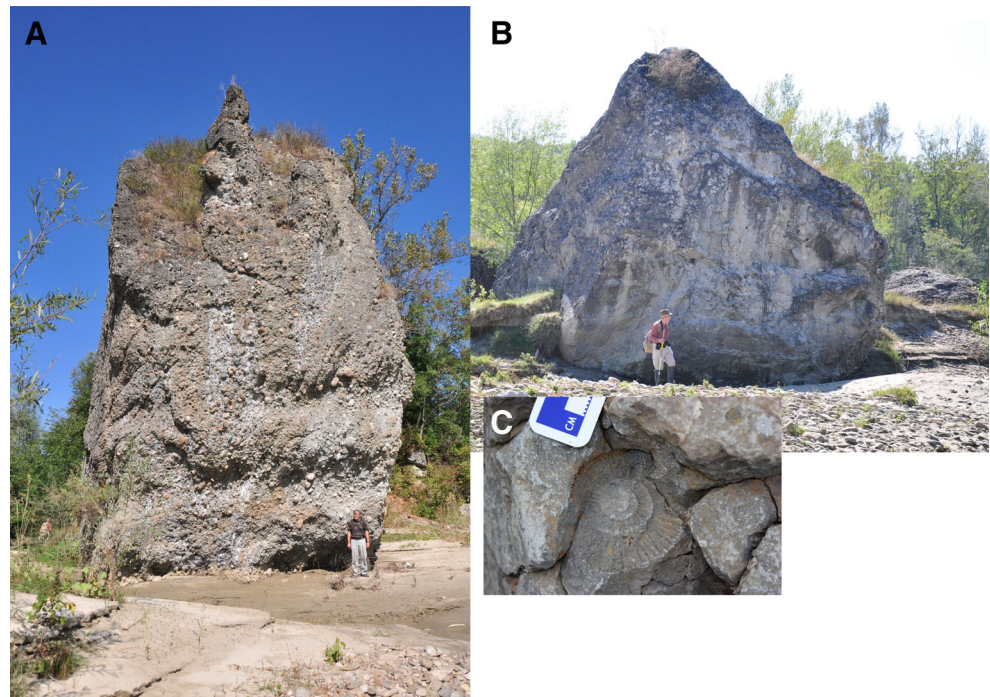
The protected palaeontological assemblages of this site refer exclusively to the content of the Jurassic limestones, which frequently comprise corals, echinoderms, brachiopods, molluscs (mainly '*Nerina*') and red algal nodules. The microfungal content is represented by foraminifera (i.e., *Miliolida*, *Textularia* and *Rotalia*), calcified radiolarians (*Spumellaria* and *Nasselaria* genera), ostracods and bryozoans, as well as uppermost Jurassic to lowermost Cretaceous calpionellids, i.e. *Calpionella alpina* (Pană and Nimigeanu, 1981). Rare cephalopod (ammonite) species, mainly belonging to the Perisphinctidae, may be found as well (Fig. 5B).

Babele (Old Ladies) from Ulmet

This site, located nearby the Boziuru locality, in the central part of BLG (Fig. 2), has a significant geotouristic potential, attracting yearly many tourists, but unfortunately it has not yet been included in the List of the Natural Reserves of Romania. The Old Ladies from Ulmet are well known due to the occurrence of concretions (described in Romanian geological literature as 'trovant', by Murgoci 1907). Due to their shape (Fig. 6A), people named these rocks 'The Old Ladies' (= Babele), describing them as 'living stones' or 'growing stones'.

The concretions appear on crest alignments at the northern end of the Ulmet village (Fig. 6B). The occurrence of the concretions requires the existence of sandy sediments, in addition to the presence of a significant quantity of carbonate-bearing fluids, conditions fulfilled in the region due to the presence of Middle Miocene (Sarmatian) sandstones. Parallel and crossed lamination may be observed in the sandstone beds, suggesting deposition in a marine palaeoenvironment.

Fig. 5 The geological and palaeontological site The Limestone Blocks from Bădila. **a** Conglomerate block containing green schist and Jurassic limestone elements in a calcareous matrix. **b** Rock block of Upper Jurassic limestone. **c** Jurassic ammonite (genus *Perisphinctes*) mould on the limestone



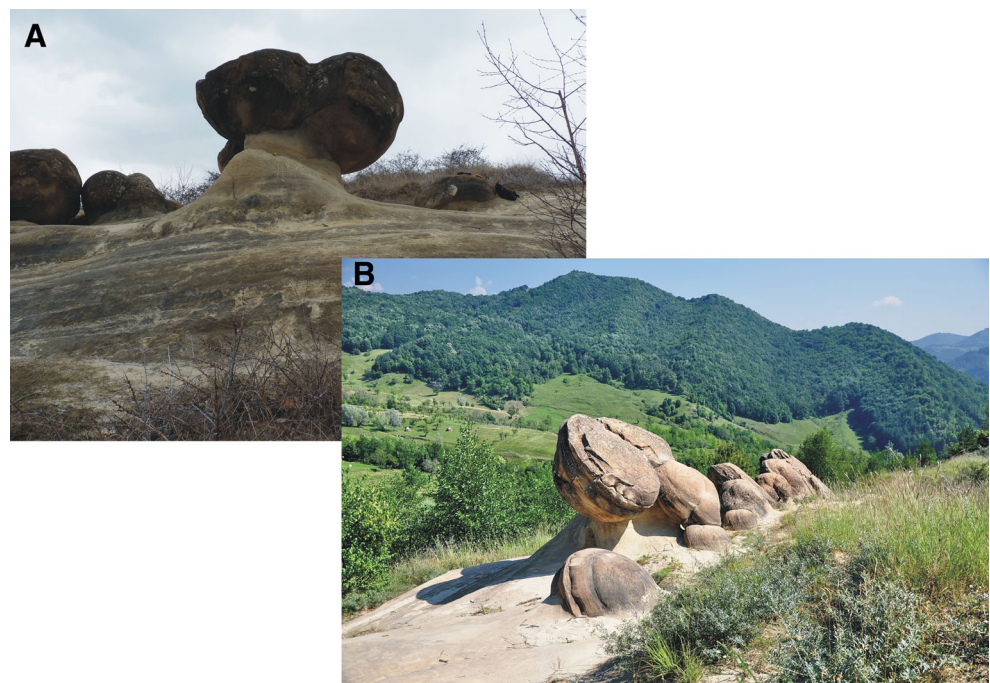
Some concretions are already detached from the basement, while others are embedded in the sandy substratum. Most concretions are spherical; some of them contain at their base microconglomerates with green schist clasts that most probably proceed from an outer source, located in the eastern part of the Carpathian bend.

It is assumed that the Ulmet concretions formed during early diagenesis processes of the Middle Miocene sandy sandstones. Their development is linked to the presence of highly

porous sandy sediments, along with a variable dispersal of the minerals that locally concentrated; a significant circulation of carbonate-rich fluids in the sandy sediments would also have present.

Within the Old Ladies from Ulmet, some macrofossils, such as gastropods (mainly *Cerithium* spp.) and bivalves may be found. Most of them are Eastern Paratethyan endemic species that belong to the genera *Mactra*, *Cryptomactra*, *Cardium* and *Tapes*.

Fig. 6 The ‘Old Ladies from Ulmet. **a** Concretions almost detached from the sandy substratum. **b** Alignments of the Middle Miocene concretions on crests close to the Ulmet village



The Mineral Springs from Fişici

The occurrence of the mineral springs in the central part of the BLG, at the Fişici locality, is linked to the presence of Oligocene-Lower Miocene bituminous facies of the Kliwa Sandstone, cropping out in the Tarcău Nappe (Figs 2 and 7D). These rocks represent the main source and reservoir deposits for hydrocarbons in the Eastern Carpathians.

In the Fişici area, there are impressive outcrops of Oligocene-Lower Miocene sandy sandstones, in metric beds, interbedded with bituminous clays, marls and cherts. Due to the high geochemical composition variation of the surrounding rocks, the mineral springs from Fişici are known to have a great variety of colours, odours and flavours. For instance, the sulphur springs are whitish-pink, those containing iron are reddish and the springs with high hydrocarbon content are blackish (Figs. 7A, B and C). Local people described these springs as ‘living water’ (those lightly coloured) and ‘dead water’, referring to the darkish ones.

As in many Romanian regions, since ancient times, local people have used the mineral springs from Fişici for their curative effects, especially for digestive and rheumatic diseases. Until to 1990, a resort was situated in the village, including a sanatorium and a public bath, but unfortunately now everything is in decay.

At the present, the springs from Fişici have a constant high flow, keeping their hydrodynamic characteristics during the

whole year, including drier periods. Possibly, in the future, the springs will show a pulsating flow, as in the region, the environment and climate are rapidly deteriorating, because of excessive timber cutting and a significant decrease in precipitation.

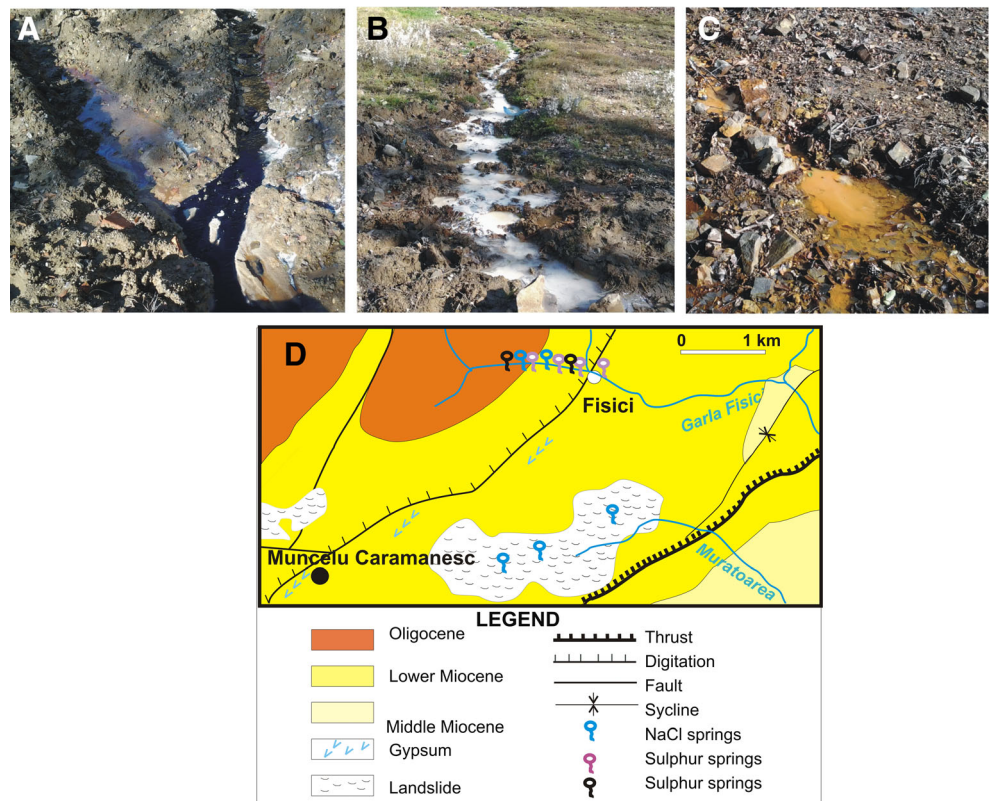
The Mud Volcanoes from Berca

These sites are the most representative for the geological heritage of the BLG, registering a high number of visitors all over the year. The mud volcanoes located near the Berca locality are also the most famous in Romania, and are also well known elsewhere in Europe.

In the region, the phenomenon occur at four separate locations, i.e. Beciu, Pâclele (namely also Fierbători), Pâclele Mari (The Big Mud Volcanoes) and Pâclele Mici (The Small Mud Volcanoes), from which only the latter two are protected areas, being also included since 2008 as NATURA 2000 sites. Initially, an area of 30 ha was declared protected in the year 1924, while now the protected sites cover 93.8 ha.

The mud volcanoes from the Berca region have been known by local people for a very long time, and they named the surrounding area ‘The Dragon Hills’, probably due to the strong gas emanations in the region. The first reference in the geological literature was made by the French geologist

Fig. 7 The mineral springs from Fişici. **a - c** Mineral springs, with high content of hydrocarbons, NaCl and Fe, respectively. **d** Geological map of the BLG area where the mineral springs occur (modified after Ştefănescu et al. 1993)



Coquand (1867), followed by the Romanian geologist Cobălcescu (1883).

Possibly, a link exists between the occurrence of the mud volcanoes in the Berca region, the intensity of the mud and gas emanations and the seismicity of the region, as it is situated some 50 km north from one of the most seismically active zone in Europe, the Vrancea area (Baciu et al. 2007). Geologically, the mud volcanoes of BLG appear in the folded Inner Foredeep of the Eastern Carpathians (Fig. 8), along the axis of the faulted anticline Berca-Beciu-Arbănași anticline (Ciocârdel 1949), striking NS and affected by longitudinal and transverse faults. In the axis of the anticline Upper Miocene (Maeotian)

deposits were sedimented, while on the flanks the uppermost Miocene-lowermost Pliocene, (i.e. Pontian), sediments occur, covered by the Pliocene deposits (Dacian and Romanian).

Pâclele Mari (The Big Mud Volcanoes) is a geological, botanical and zoological nature reserve, in the administrative territory of the Scorțoasa locality. This area has been included since 2000 in a Geological and Palaeontological Nature Reserve, corresponding to the IUCN category IV. The site is situated at an altitude of 322 m and comprises a surface of 22 ha; its name is connected to the large size of three cones, 1.5–2 m in height, placed in the central part of the plateau.

Pâclele Mici (The Small Mud Volcanoes) (Fig. 9) is a geological and botanical nature reserve, placed on the administrative territory of the Berca locality. This area has been included since 2000 in the Geological and Palaeontological Nature Reserve, corresponding to the IUCN category IV. The site is situated at 341 m altitude, spread on 16.5 ha. The crater diameter of the Small Mud Volcanoes varies between 10 and 200 cm.

Both protected sites contain highland surfaces with active and inactive cone-shaped vents, which are commonly up to 2 m tall. A high number of surface vents, pools, cones and holes may be seen, i.e. 64 at Pâclele Mari and 37 at Pâclele Mici, from 2010 to the present, but their number is variable in time (Brustur et al. 2015).

Salty waters occur together with the mud, along with numerous oil pellicles. Due to the salty soil, scarce or anomalous vegetation is present nearby the active vents, but also around the inactive ones. Halophyte plants, such as *Nitraria schoberi* and *Obione verucifera*, grow on the margin of the mud volcano fields, their occurrence being unique in Europe (Evelpidou et al. 2010).

The protected faunas comprise small mammals, such as ground spirrels (*Spermophilus citellus*), turtles (*Emys orbicularis*), frogs (*Bombina variegata*) and lizards, i.e. *Lacerta praticola* and *Elaphe sauromates* - the last species known to local people as “The big dragon”.

Methane emissions of the mud volcanoes from the Pâclele Mari and Pâclele Mici sites have been estimated at 730 tones/year and 383 tones/year, respectively (Etiopie et al. 2004). The composition of the exhalations recorded in all the sites of mud volcanoes from Berca is comparable; the gas contains over 95 % CH₄ and a very small quantity of CO₂, up to 3 %.

Taking into account these data, only one gas reservoir is suggested to account for the gas composition of the mud volcanoes. This composition corresponds also to that recorded in the drillings located in the Berca region, from cores taken at around 3000 m depth (Voicu 1975). Probably, the gas mainly containing CH₄ comes from this depth, where Middle Miocene deposits of the regional Sarmatian stage, known to contain hydrocarbons, have been intercepted.

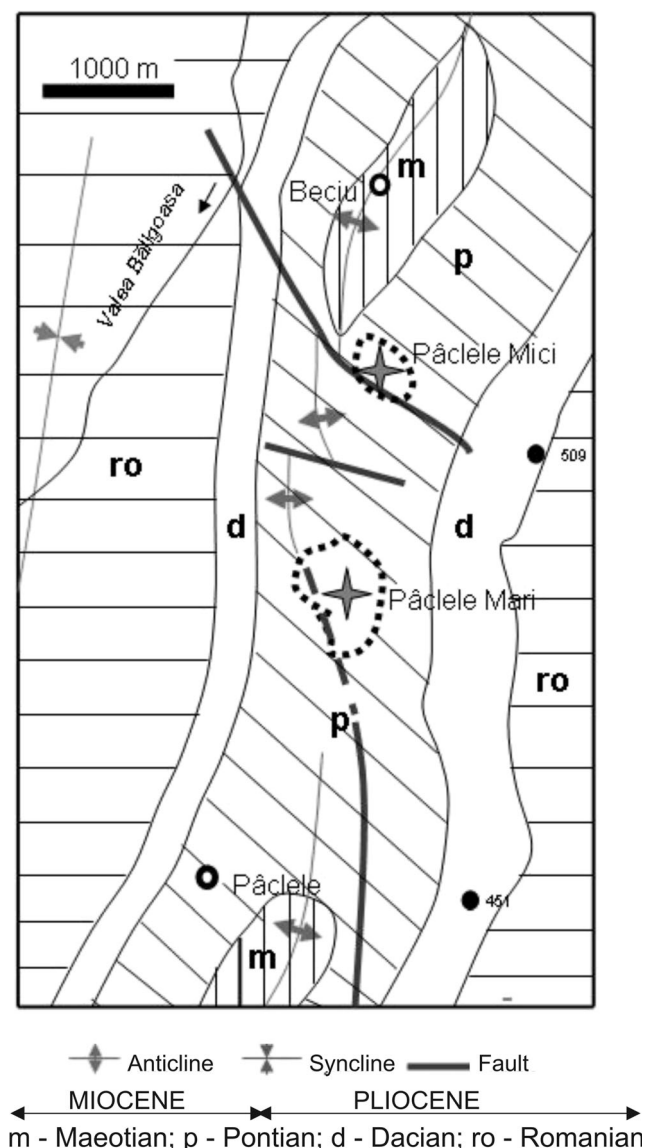


Fig. 8 Geological map of the Berca region (after Brustur et al. 2015 and Ciocârdel 1949), showing the location of the four zones with mud volcanoes occurrences (from N to S): Beciu, Pâclele Mari, Pâclele Mici and Pâclele (=Fierbători)

Fig. 9 The site of the Pâcelele Mici, with an active emanation vent and several inactive cone-shaped structures



The White Stone ‘La Grunj’

This site, located within the [Mânzălești](#) locality, in the NE part of BLG, has been included since 1995 in the Geological and Palaeontological Nature Reserve, corresponding to the IUCN category III. The protection refers to a white stone (Fig. 10) of Middle Miocene in age (corresponding to the Badenian regional stage). The stone occupies a surface of 0.025 ha at the base, is 18 m in height and 15 m in diameter.

The white stone is composed of volcanic ash re-sedimented in a marine palaeoenvironment, as marine microorganisms (planktonic foraminifers and calcareous nannoplankton belonging to the NN5 biozone) have been identified, as in similar rocks of Badenian (Middle Miocene) age in the southern Eastern Carpathians (Melinte-Dobrinescu and Stoica 2013). In the White Stone ‘La Grunj’, there are interbedded marls rich in foraminifers, the so-called “Globigerina marls”, composed of grey-brownish and greenish marls, commonly containing *Praeorbulina transilvanica*, *P. glomera*, *Candorbulina*

universa, *Globorotalia mayeri*, *G. bykove*, *Globigerinoides triloba* and *G. irregularis* (Popescu and Crihan 2011).

The Meledic Plateau

This is the biggest nature reserve in all the BLG, comprising, since 2000, an area of 136 ha of geological, speological, botanical and zoological Nature Reserve, corresponding to the IUCN category IV. The site is located in the administrative territories of the [Lopătari](#) and [Mânzălești](#) localities, in the NE part of the BLG (Fig. 2), at the contact between the Subcarpathian Nappe and the inner (western) Tarcău Nappe. From geological point of view, some unique phenomena occur.

The Salt Mountain is represented by massive salt deposits, interbedded with reddish, green and grey clays. In general, the occurrence of the lowermost Miocene (Aquitaniian-Burdigalian) salt is linked to diapirism, as indicated by the presence of chaotic salt breccia deposits. In this breccia,

Fig. 10 The White Stone ‘La Grunj’, exposing volcanic ash resedimented in a Middle Miocene marine palaeoenvironment



various clasts include bituminous sediments of the Oligocene, conglomerates with elements of green schists of outer (eastern) provenance as the Eastern European and Scythian platforms, and also younger Miocene rocks, all pierced by the salt. Rarely, fragments of corals from Middle Miocene deposits of the eastern platforms are encountered. At the base of the slopes, salt springs occur, as well as small caves produced by the dissolution of the salt.

The topography of the plateau consists of single or twin extremely broad and deep (up to 25 m) sinkholes with steep slopes, deep ditches cut in salt and clay, deep ravines and caves. Of high significance from scientific and touristic perspectives are hills, canyons, caves, lakes, wooden statues and a characteristic fauna including scorpions and turtles.

On the Meledic Plateau, there are lakes with fresh water, not salty as expected. When rain water infiltrates the salt, the salt dissolves only in small cone shapes, as the salt is covered by a thin layer of clay, which is an impermeable rock. The most important lakes are the Meledic Lake, also known as the Bottomless Lake with a maximum depth of 5.4 m, and the Castle Lake, having a maximum depth of 3.9 m.

In the same plateau there are 47 saline endocarsts, including Europe's biggest salt cave, and the second in the world. The cave "6S Meledic", located in the northern part of the plateau, has 1257 m in length and 32 m depth, and was declared in 1980 as the longest salt cave in the world. Stalactites of diverse colours, i.e. white, yellow, pink, reddish, grey and brown, as well as stalagmites, up to 15–20 cm in height may be seen (Giurgiu 1985). The record of "6S Meledic" was maintained until 1983, when the ICRC (MALHAM) cave from Israel (Frumkin 1995) was discovered and became the longest salt cave in the world.

The Everlasting Fires

In an area of around 100 m² nearby the Terca village (W of the Lopătari), there are significant gas emanations, linked to the existence at depth of faulted Miocene rocks with a high hydrocarbon content. "Everlasting fires" here show a variable intensity, linked to the gas emissions (mainly methane) and the seismic activity of the area, which creates new subsurface faults in the Miocene sediments. The flames of the fires can reach 1 m height.

The Neogene Fossiliferous Sites

In the Slănicul de Buzău Valley, within the NW part of the BLG, two stratotypes belonging to the Pliocene and Pleistocene Eastern Paratethyan stages, namely the Dacian and the Romanian, have been defined. The Pliocene Dacian stage corresponds to the upper Zanclean-upper Piacenzian,

while the Romanian stage covers the Late Pliocene-Late Pleistocene interval, extending from the upper Piacenzian to the Ionian (Andreescu 1972; Papaianopol et al. 1995; Snell et al., 2006; Piller et al. 2007). The depositional palaeosetting of the Dacian and Romanian stages progressively shifted from brackish to fresh water (Jipa and Olariu 2013). Lithologically, the Dacian and the Romanian successions are mainly clays and silts, containing thin cm up to dm coal levels and sands, especially towards the top of the Pliocene and within the Pleistocene (Fig 11).

The Dacian Stage was firstly introduced by Teisseyre (1907), who separated it based on macrofaunas (molluscs); the holostratotype of the Dacian was later selected by Andreescu (1972) in the Slănicul de Buzău Valley. The base of this stage is marked by the occurrence of bivalve assemblages with endemic species of *Pachydacna*, *Parapachydacna*, *Stylodacna* and *Zamphiridacna*. The lower part of the Dacian stage, i.e. the Getian Substage, mainly contains the molluscs *Prosodacna*, *Stylodacna*, *Limnocardium*, *Phyllocardium*, *Viviparus*, *Pachydacna*, *Zamphiridacna*, *Dacicardium*, *Pseudocatillus* and *Dreissena*. The upper part of the Dacian stage, namely the Parscovian substage, is characterized by the presence of a mollusc fauna with *Prosodacna haueri* Cobălcescu, *Stylodacna heberti* (Cobălcescu), *Viviparus rumanus* Tournouer, *Prosodacna (Psilodon) conversus* Papaianopol, *Limnodacna rumana* Papaianopol and Motaş, *Dacicardium rumanum* (Fontannes) and *Viviparus heberti* Cobălcescu. All these macrofaunas may be observed in the BLG territory, at the holostratotype and in complementary sections, situated in the Slănicul de Buzău basin (Fig. 12A).

The Romanian stage was firstly introduced by Krejci-Graf (1932). Its holostratotype (Macarovici 1961; Andreescu 1972; Papaianopol et al., 2003) in the Slănicul de Buzău basin, is characterized by the presence of silty clays, coquinas, sands and several lignite beds, up to 0.5 m in thickness. The uppermost Dacian and the lowermost Romanian sediments contain many macrofossils, such as gastropods and bivalves (Figs. 12B and C). The top of the Dacian is characterized by a high abundance of bivalve species *Prosodacna euphrosinae* Cobălcescu. Typical fossil assemblages of the Romanian stage contain endemic macrofaunas, such as *Jazkoa sturdzae* (Cobălcescu), *Psilunio slanicensis* (Teisseyere), *Prosodacnomya sturi* (Cobălcescu) and *Viviparus bifarcinatus* (Bieltz).

Neither of the two stages stratotypes and their rich macrofaunal context is protected. As many outcrops exposing the fossiliferous sediments of the Dacian and Romanian are easily accessible, the fauna is being collected without control. Moreover, most of the fossils are found in outcrops situated in the bank rivers, hence may be easily eroded during flood events. Taking into account that all these fossils (mainly bivalve and gastropods) are of the highest scientific value, and including endemic taxa, a protection of both historical stratotypes of the two stages is essential.

Fig. 11 The nature reserve the Meledic Plateau: The Salt Mountain downstream the village of Lopătari, on the left bank of the Slănicul de Buzău Valley



Geological Heritage Legal Frameworks

There are several main regulations in Romania to which reference will be made in the process of the Buzău Land Geopark establishment, including: the Ordinance 187/1990 regarding the protection of World Cultural and Natural Heritage; Law no. 58/1994 ratification of the Convention on Biological Diversity; Law no. 13/1993 ratifying the Convention on the Conservation of European Wildlife and Natural Habitats in Europe; Law no. 5/2000 on national territory planning -

Section III, protected areas; Law no. 462/2001 approving Government Emergency Ordinance no. 236/2000 regarding the regime of protected natural areas, conservation of natural habitats, of wild flora and fauna; Governmental Decision 230/2013 on the delimitation of biosphere reserves, national and natural parks and the establishment of their administrations; Law no. 451/2002 to ratify the European Landscape Convention; Order no. 552/2003 approving the internal zonation of national and natural parks, in terms of the need for conservation of biological diversity; Governmental Decision 2151/2004 regarding the establishment of new protected area; Order no. 494/2005 on the procedure of entrustment of administration and award custody of protected natural areas (Andrășanu 2007).

In addition, Romania is one of the first countries to recognize the Geopark as a distinct protected area. Hence, in the Government Emergency Ordinance No. 57/2007, a Geopark is defined as a protected natural reserve (terrestrial, aquatic and/or underground), in which there are present plant and wild animal species and also biogeographical, landscape, geological, palaeontological, speleological or other elements and formations with a significant ecological, scientifically and/or cultural value. These references are in a full agreement with the IUCN definition regarding Geoparks as “A clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values”.

In the Buzău Land Geopark, there are two categories of IUCN protected areas: the category III, comprising “natural monument or feature: areas set aside to protect a specific natural monument, which can be a landform, sea mount, marine cavern, geological feature such as a cave, or a living feature such as an ancient grove”, and category IV, including “habitat/species management area: areas to protect particular species or habitats, where management reflects this priority”. As described above, some of the protected areas in the Buzău Land Geopark are both IUCN categories III and IV, and need to be regularly and actively monitored, while other significant sites, especially palaeontological, need to be declared as natural protected areas and included in an IUCN category.

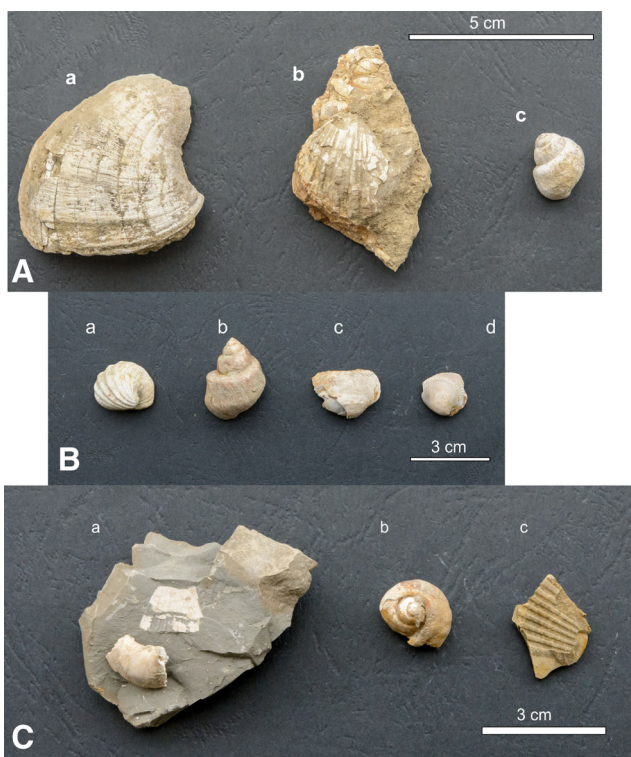


Fig. 12 Pliocene macrofossils identified in the BLG area, at the stratotypes of the Dacian and Romanian stages, in Slănicul de Buzău Basin. **a** Lowermost Dacian faunas from Câmpulunganca. a – *Stylodacna* sp.; b – *Zamphiridacna zamphiri*; c – *Viviparus* aff. *Heberti*. **b** Macrofaunas of the uppermost Dacian deposits at the stratotype of the Romanian stage. a – *Prosodacna (Psilodon) haueri*; b – *Viviparus cucestiensis*; c – *Psilunio* sp.; d – *Prosodacnomya* sp. **c** Macrofaunas of the lowermost Romanian stage at the stratotype. a – *Unio* sp. (fragments); b – *Valvata (Cincinna)* sp.; c – *Limnocardium* sp.

Overall, we are confident that cooperation with all the implied stakeholders as well as the national and regional authorities, along with the sustainable projects development will support the improvement of the Buzău Land Geopark management and visibility. The final goal is that the Buzău Land Geopark, which reflects a very rich Earth history, nature, culture and traditions, joins the European Geoparks Network and the UNESCO Global Geoparks.

Geoheritage, Geoconservation and Geotourism

The Buzău Land Geopark, located in SE Romania, at around 100 km N from Bucharest, the capital town of Romania, is easily accessible. The BLG territory covers about 1100 km² and comprises 18 parishes and a population of around 45,000 inhabitants (Andrășanu et al. 2015).

In the BLG, there are unique geological sites in Romania, which may be seen within a relatively small territory. In general, is not common globally to have such a density of various geological phenomena, including mud volcanoes, amber occurrence, salt caves, oil springs, natural gas fires and fossils from Mesozoic to the Pliocene, grouped within a relatively small territory. In addition, the sedimentary rocks cropping out in the BLG, are folded and overthrust, show various lithological features and were deposited in different palaeoenvironments, such as deep marine, shallow marine, brackish and fresh-water, encompassing a geological history covering more than 70 Ma, from the Upper Cretaceous to the Quaternary.

In the area of BLG, two thematic museums supporting the geosciences are already opened to the public. One of them, The Amber Museum, is situated in Colți village, and exposes rocks from the region containing amber pieces, some of them of over 1.5 kg, as well as diversely coloured jewellery and tools for extracting and processing amber.

The second BLG museum, ‘The Time of the Man’, was opened in 2015, due to the joint efforts of scientists from the National Museum of the Romanian Peasant and the Institute of Geodynamics of the Romanian Academy, and is located in the Mânzălești locality, near the protected site ‘The white Stone at Grunj’. In this museum, the connections between people and the Earth are explored, along with an introduction to local traditions.

The geotourism of the BLG could be successfully completed with cultural tourism, as in the region there are many remarkable historical monuments, including the rupestrian settlements in the Aluniș – Bozioru area. Archaeological finds indicate very old settlements, from the Bronze Age, Monteoru Culture, or the beginning of the Iron Age, Hallstatt Culture, while some of caves have remains dated from the early Christian period, i.e. the sixth Century. Additionally, in the BLG territory, there are ruins of former medieval settlements, various archaeological sites and medieval monasteries.

Besides oil extraction, developed in the SE part of the BLG near the Berca locality, no industries are developed in the Geopark territory. The area is mainly rural, with currently very limited possibilities for development. Many localities are isolated, due to their geographical position and lack of the infrastructure, some being inaccessible from late autumn till late spring. However, these disadvantaged areas have permitted the preservation of a distinctive cultural identity for the people living in the BLG territory, which is intimately linked to the vast natural scenery.

Concerning the sites of the BLG, although many are of high scientific significance, many are still unprotected and vulnerable to various pressures. The BLG territory is closely situated to one of the most seismically active zone in Europe; this feature, along with the emplacement of some sites on river banks, also contributes to this vulnerability.

Most of the sites containing unique Pliocene to Pleistocene macrofaunas with endemic taxa are accessible and could be easily damaged by casual fossil collecting. Additionally, there are many small outcrops where the fossil-bearing resource is very limited and could in theory be totally removed in hours using appropriate equipment, and/or where fossils of the highest scientific value are to be found and could be targeted by irresponsible, non-scientific collectors.

For all these reasons, it is essential to promote in the BLG territory a responsible approach during geotouristic activities. It is also necessary to gain full support for encouraging initiatives that increase awareness and understanding of the value of the sites and the need to conserve them. This task may be accomplished only through a close collaboration between the local and regional authorities and the geological community, to ensure that maximum educational and scientific gain is made from the geological and palaeontological resources.

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