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GEOLOGICAL - PALEONTOLOGICAL ATLAS OF THE BUZĂU LAND GEOPARK (BLG)

GeoEcoMar
2019

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Descrierea CIP a Bibliotecii Naţionale a României
Geological and palaeontological atlas of the Buzău Land geopark / Titus Brustur, Rodica Macaleţ, Dan Jipa, ... - Bucureşti : GeoEcoMar, 2019
Conţine bibliografie
ISBN 978-606-9658-02-4

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1. INTRODUCTION

Since the last 150 years, many Romanian and abroad geologists studied various geological aspects, including paleontological ones, of the Buzău Land Geopark (BLG) and surrounding areas (**Plate 0**). Therefore, generations of geologists investigated the lithology and biostratigraphy of this territory, along with tectonics and mineral resources that are very rich (i.e., hydrocarbons, salt and amber). Recently, some new data regarding the natural patrimony of the BLG were published (Melinte-Dobrinescu *et al*., 2016)[1].

The geology of the Buzău Land Geopark, placed in the southern part of the Eastern Carpathians, is quite complicated, showing Alpine tectonics, characterized by nappe system structures. The nappes were involved in two main tectonic phases, 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, structures that are included in the Tarcău Nappe (towards West) and the Subcarpathian Nappe (towards East). In the eastern extremity of the BLG, the deposits of the Carpathian Foredeep occur (**Plate 1**).

The territory of the BLG exposes Upper Cretaceous, Paleogene, Miocene, Pliocene and Pleistocene successions. The Upper Cretaceous hemipelagic sediments (variegated clays and marls) and calcareous turbidites are followed by the Paleocene and Eocene turbidites, dominated by thick arenites and Oligocene bituminous rocks (Motaş *et al*., 1967[2]; Dumitrescu *et al*., 1968[3]; Ştefănescu *et al*., 1988[4]; Melinte, 2005[5]). The base of the Miocene is characterized by the occurrence of salt diapirs. From the base of Miocene, thick turbidites and molasse deposits started to accumulate. The Lower Miocene marine paleoenvironment progressively shifted to a brackish one in the Middle Miocene, while from the Lower Pliocene a fluvial-lacustrine deposition was settled (Jipa & Olariu, 2009)[6].

[1] Melinte-Dobrinescu M.C., Brustur T., Jipa D., Macaleţ R., Ion G., Ion E., Popa A, Briceag A. (2016). *The Geological and Palaeontological Heritage of the Buzău Land Geopark (Carpathians, Romania)*. Geoheritage, **9**: 225-236.
[2] Motaş I., Bandrabur T., Ghenea C., Săndulescu M. (1967). *Ploieşti Sheet, 1:200,000*. Printed by the Geological Institute of Romania.
[3] Dumitrescu I., Săndulescu M., Bandrabur T., Săndulescu J. (1968) *Covasna Sheet, 1:200,000*. Printed by the Geological Institute of Romania.
[4] Ştefănescu M., Popescu I., Ştefănescu M., Melinte M., Ivan V., Stănescu V. (1989). *Aspects of the possibilities of the lithological correlations of the Oligocene-Miocene Boundary in the Buzău Valley*. Romanian Journal of Stratigraphy, **75**(4): 83–91.
[5] Melinte M. (2005). *Oligocene paleoenvironmental changes in the Romanian Carpathians, revealed by calcareous nannofossil fluctuation*. In Tyszka, J., Oliwkiewicz-Miklasinska M., Gedl, P., Kaminski, M. A. (eds.) Methods and Application in Micropaleontology. Studia Geologica Polonica, **124**: 15–27.
[6] Jipa D.C., Olariu C. (2009). *Dacian Basin. Depositional architecture and sedimentary history of a Paratehys sea*. Geo-Eco-Marina Special Publ., **3**, 264 p.

Starting from the base of the Oligocene, when firstly the Paratethyan Realm isolated from the Tethys, the whole Eastern Carpathian area was included in 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.

2. GEOLOGICAL AND PALEONTOLOGICAL OBJECTIVES

2.1. TARCĂU NAPPE

Brief history of the geological-paleontological knowledge. In the outer (easternmost) area of the Paleogene deposits belonging to the BLG, in the turbidite facies, Stoica (1945)[7] remarked the frequent occurrence of "hieroglyphic strata", occurring in the Eocene deposits from the Sibiciu Valley, along with the facial variation of the Oligocene sediments, from E to W. Later, Grigoraş (1955)[8], defined in the Eocene deposits the Colţi Facies. This is different from the Tarcău Facies, which is mainly composed by sandy turbidites, i.e., thick-m sandstones rhythmical alternating with cm to dm-thick grey-green pelites. By contrast, the Colţi Facies is made by shally turbidites, made by prevailing grey-greenish pelites and dm-thick sandstones with numerous hieroglyphs. Significant advancement in deciphering the geology of the inner and outer flysch zones (i.e., the Inner and Outer Moldavides of the Eastern Carpathians) from the BLG territory and surrounded areas were made by Murgeanu *et al*. (1961)[9], whose results were integrated, along with new data on the Geological maps scale 1:200,000 - Sheet 29 Covasna (Dumitrescu *et al*., 1968) and Sheet 36 Ploieşti (Motaş *et al*., 1967). Until now, in the BLG area only one map at the scale 1:50,000 was published – Sheet Nehoiu made by Ştefănescu *et al*., 1993[10]. Additionally, the Paleogene lithostratigraphic units of the Tarcău Nappe exposed in the Buzău Valley were investigated from sedimentological point of view (Vârban *et al*., 2001[11]; Frunzescu & Brănoiu, 2004[12]) and paleoichnological one (Brustur, 1995[13]; Buatois *et al*., 2001[14]). The Oligocene-Early Miocene interval and associated litho- and biostratigraphical changes were pointed out by Rusu *et al*. (1996)[15].

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[7] Stoica C. (1945). *Paleogenul din valea Sibiciului (nota preliminara).* Rev. Min. Geol., Cluj, **III**(1): 64-85.
[8] Grigoraş N. (1955). *Studiul comparativ al faciesurilor paleogenului dintre Putna şi Buzău*. An. Com. Geol., **XXVIII**: 99-219.
[9] Murgeanu G., Filipescu M.G., Patrulius D., Alexandrescu Gr., Tocorjescu M., Mutihac V., Contescu L., Săndulescu M., Jipa D., Săndulescu J., Mihăilescu N., Bratu E., Bombiţă Gh., Iliescu G., Panin N., Butac A. (1961). *Ghidul excursiilor, B - Carpaţii Orientali*. Asoc. Geol. Carp.-Balc., Congr. V, 100 p., Bucureşti.
[10] Ştefănescu, M., Popescu, I., Melinte, M., Ivan, V., Ştefănescu, M, Papaianopol, I., Popescu, G., Dumitrică, R. (1993). *Sheet Nehoiu*, scale 1: 50,000. Printed by the Geological Institute of Romania.
[11] Vârban B., Derer C., Anastasiu N., Roban R.-D., Popa M. (2001). *Architecture of turbidite systems as revealed by the East Carpathians Paleogene sequences ("Tarcău Formation" – Siriu, Romania).* St. Cerc. Geologie, **46**: 19-37.
[12] Frunzescu D., Brănoiu Gh. (2004). *Monografia geologică a bazinului râului Buzău*. 458 p., Ed. Univ. Ploieşti.
[13] Brustur T. (1995). *Studiul paleoichnologic al formaţiunilor cretacic-miocene din Moldavidele externe*. Rezumatul tezei de doctorat, Univ. Bucureşti, 24 p.
[14] Buatois L.A., Mangano M. G., Sylvester Z. (2001). *A diverse deep-marine ichnofauna from the Eocene Tarcau Sandstone of the Eastern Carpathians, Romania*. Ichnos, **8/**1: 23-62.
[15] Rusu A., Popescu Gh., Melinte M. (1996). *Oligocene-Miocene transition and main geological events in Romania.* A. Excursion Guide.

2.1.1. The ichnological content of the Colţi Facies (Eocene)

The facies developed on the limited area, in the eastern area of the Tarcău Nappe development, being located in the outer part of the Eocene Tarcău Facies. The later one developed on large areas on the BLG territory. The succession exposed around the Colţii de Sus village is characterized by the deposition of shally turbidites, i.e., rhythmical alternating pelites and thin cm up to dm sandstones frequently showing mecanoglyphs (current traces) and a poor inchnofauna dominated by the ichnospecies *Ophiomorpha rudis* (KSIAZKIEWICZ) (**Plate 2a, b**). Rarely, few ichnofauna *Thalassinoides* isp. (**Plate 2c**), ?*Asteriacites* isp. (**Plate 2d**), *Planolites* isp. (**Plate 2e**) and *Helminthopsis* isp. (**Plate 2f**) are present. According to Uchman (1999)[16], *Ophiomorpha rudis* is "a very deep-feeding burrow system composed of oblique to vertical shafts and horizontal galleries produced by shrimp-like crustaceans". The trace fossils are very important in paleoenvironmental reconstruction. Sometimes, laymen could erroneously interpret the presence of the trace fossils on sediments. For instance, Stanciu Duran (2015)[17] assumed that they are testimonies of a "pelasge writing" attributed to an ancient population living in the Buzău Mountains.

2.1.2. The Kliwa Formation (Oligocene)

In the outer part of the Tarcău Nappe developed the bituminous facies of Kliwa (Ștefănescu *et al*., 1993), largely exposed in the W area of BLG. The facies started to be deposited in the Lower Oligocene up to the Lower Miocene (Melinte, 2005), being characterized by the presence of sandy turbidites, i.e., quartzous sandstones rhythmically alternating with bituminous shales, namely disodiles, bituminous marls and siliceous rocks (menilites). In the BLG territory, as in the whole outer Eastern Carpathians, the Kliwa Sandstone facies is divided into two formations: Lower Kliwa (Oligocene in age, i.e., Late Rupelian to Chattian) and Upper Kliwa (Early Miocene in age, i.e., Late Aquitanian to Burdigalian). The two aforementioned units are separated by uppermost Oligocene-lowermost Miocene (Late Chattian to Early Aquitanian) shally turbiditic successions with calcareous sandstones (Ștefănescu *et al*., 1989; Melinte, 2005).

In the Colţi area, the Oligocene-Miocene sediments of the Kliwa Formation show many folds, included in axial faulted synclines and anticlines, developed directionally on several km. In the aforementioned area, the Kliwa Formation is up to 400 m stratigraphically thick, with folds and faults (**Plate 3a, b**); massive m-thick sandstones are outcropping, along with bituminous pelites. In

Rom. J. of Paleontology, **76/**1: 3-21.

[16] Uchman A. (1999). *The Ophiomorpha rudis ichnosubfacies of the Nereites ichnofacies: characteristics and constraints*. Palaeoclimatology, Palaeogeography, Palaeoecology, **276**: 107-119.

[171] Stanciu Duran M. (2015). *Perieghează detectivă. Nucu-Bozioru Raport preliminar 2013-2014*. Editura Teocora.

the NW part of the BLG, around the Lopătari locality, the Kliwa Facies is characterized by shally turbidites (**Plate 4a**), while in the Bozioru region, the vertical m-thick massive sandstones are described by the local people as the "Giant Wall" (**Plate 4b**).

Sandstone beds with reduced hardness have enabled the enlargement of natural cavities or carving of shelters and places of worship which form the group of cave churches from Buzău Mountains, i.e., Bisericuţa lui Ioan Bogoslov (Ioan Bogoslov's Church) – **Plate 5a** and Chilia lui Dionisie (Dionisie's cell) - **Plate 5b**. These shelters have mostly medieval origins and are located in the surroundings of Bozioru, Colţi, Cozieni and Brăeşti communes, all included in the BLG territory. A similar church is located in the Aluniş village, not far from the "Amber Museum" located in the Colţi locality. None of the above described sites are protected areas.

2.1.3. The Buzău Amber (= *Chihlimbarul de Buzău*)

The amber exploitation in the BLG territory has its origins in immemorial times, when locals used primitive tools to dig out many stones for commercial purposes. Sometimes, this was the only way locals could earn their living, by extracting and processing amber to support the economy of the region. Locals used the stones to make jewels as well as religious objects. This amber was firstly mentioned in the year 1578, when Mihnea Vodă and his lady, Doamna Neaga, who ruled the Romanian province Wallachia (actually Muntenia) during those times, visiting the church from Aluniş, endowed the settlement with land that produced "*amber shards of rare beauty*" (Ghiurcă, 1999)[18]. For the first time, Helm (1891)[19] described the amber from the Romanian Kingdom and termed it rumanit, in order to differentiate it from the Baltic amber, which is known under the name of succinite. At the beginning of the 20th Century, Murgoci (1903)[20] published a study on the Romanian amber, indicating also the possibilities to valorize it.

The **Buzău Amber** (Coordinates: Latitude: 45°23′46.83″N; Longitude: 26°25′0.67″ E) is a protected area of national interest that corresponds to the IUCN III category (geological and paleontological natural reserve) located in the Colți village, in the SW part of the Geopark. According to the Law no. 5 from 6th of March 2000 (regarding the approval of National Territory Improvement Plan – Section III – protected areas) the Buzău Amber reserve was declared a protected area. The reserve has a surface area of 2.52 ha and is located at the base of Mount Ivănețu at an altitude of 500-600 m in the NE part of Colți village, near the county road connecting Colți with the Aluniș village. The access is made through DN10 Buzău – Întorsura Buzăului until

[18] Ghiurcă V. (1999). *Chihlimbarul şi alte resurse gemologice din judeţul Buzău*. Bul. Şt. Muz. Buzău: **5**, 389-407.
[19] Helm O. (1891). *Mittheilungen über Bernstein. XIV. Über* Rumanit*, ein in Rumänien vorkommendes fossils*. Harz. Schr. Naturf. Ges. Danzig **7**: 1869-1892.
[20] Munteanu-Murgoci Gh. (1903.) *Zăcămintele succinului din România (chihlimbar, romanit).* In: Protopopescu-Pache *et al.* (Ed.), Gh. M. Murgoci – Opere alese, 19-53, Bucureşti.

Pătârlagele, then towards the Colți and afterwards on DC71 road to the Aluniș locality. The aim of the protection corresponds only to the richest amber site in the area, Strâmba – Comarnici, one of the seven located in the region. The conservation state of the site is good. Vulnerability: landslides and unauthorized exploitation is endangering the area.

The Buzău Amber displays a dominantly yellow color, but there are over 160 colors and shades of predominant darker colors varying from red to black. Within Colţi-Aluniş area there are mainly 2 types of amber: (1) An older, primary variety of Oligocene age displaying frequent cracks impregnated with organic material; (2) A newer variety formed following type 1, probably in Miocene, which is brighter in color and deposited in the cracks of the older one (synthesis in Ghiurcă, 1999) .

Recent studies (Neacşu & Dumitraş, 2008[21]) have been focused on the petrographical features of the Romanian amber (=the Rumanit) from Buzău and compared its features with the Baltic amber (=the Succinite). By summarizing the published data, it become obvious that the amber types, i.e., Romanian and Baltic, have distinct signals in term of geochemistry, and could be distinguished by optical microscopy. This fact could offer some answers to archaeological problems related to the presence of prehistoric amber jewels on the Romanian territory, which have been regarded by some authors from a Baltic provenance. The latest works related to prehistoric origin of ornamental pieces (necklaces, pendants, etc.) of amber found in various Romanian archaeological sites were published by Boroffka (2001[22]). The main problem arises from the fact that a determination of an artefact as "Baltic amber" means a default origin of the raw material from the Baltic Sea (Boroffka, 2006[23]). Because this information has great archaeological importance for discussions about prehistoric goods and commercial connections, pyrolysis-gas chromatography and mass spectroscopy analysis (Boroffka, 2006) showed that in Romania there are at least three types of amber, one of them showing similitudes with the "Baltic amber". The Colţi Amber exhibits can be seen at the Amber Museum in the Colţi village, which is unique in Romania (**Plate 6**). After Murgoci (1903) and Ghiurcă (1999), in the Colţi area the amber occurs in 14 sites, from which in 11 it was found *in situ*, whereas in 3 localities it is a secondary deposit.

The amber from Colţi-Aluniş area has a rich content of fossilized arachnids, beetles, diptera, crustaceans, millipedes, hymenoptera, (micro) lepidoptera, reptiles, bird feathers and animal hair. Vegetal and animal organisms fossilized in the amber deposits are very important for the dating of the deposits which contain them. In general, plants and animals are very well preserved in the

[21] Neacşu A., Dumitraş D.G. (2008). *Comparative physico-mineralogical study of Romanite and Baltic amber; preliminarz FTIR and XRD data*. Romanian Journal of Mineral Deposits: **83**: 109-114.
[22] Boroffka N. (2001). *Bemerkungen zu einigen Bernsteinfunden aus Rumanien*. Archaologisches Korrespondenzblatt, **31**, 395-409.
[23] Boroffka N. (2006). *Resursele miniere din România şi stadiul actual al cercetărilor privind mineritul istoric*. Apulum **XLIII(**1): 71-94, Alba Iulia.

amber, because the resin is a very good environment for preserving bodies, leading to the rapid and accurate fossilization processes. The origin of amber nodules is found in the resin secreted by certain trees (mainly conifers) from the ancient forests, which covered during the Oligocene, about 25 million years ago, large areas of the Eastern Carpathians; in time, the plant material accumulated in different geological deposits suffered a deep anaerobic carbonization process, that favored a good fossilization of the resin. Due to the anoxic/dysoxic Oligocene paleoenvironment, the amber nodules are often directly associated with thin layers of coal.

Pioneer investigations of the Buzău Amber from a paleontological point of view belong to Protescu (1937)[24]. The author was the first to describe insect fossils from the Buzău Amber, a butterfly wing, but also several groups of organisms, such as: a pseudoscorpion **(Plate 7a**), plants fleas (**Plate 7b,d**), diptera (**Plate 7c**) arachnids, ants, termites, mosquitoes, wasps, scorpions, phalangidae and different types of larvae, along with two species of spiders (**Plate 7e, f**). As plant remnants, the above-mentioned author noticed lichens, pollen and coniferous acicular leaves. The paleobotanical study of Petrescu *et al*. (1989)[25] on fossil wood, collected from the Oligocene Lower Kliwa Formation exposed in the Colţi locality, shows the presence of the taxa *Sequoioxylon gypsaceum*, *Laurixylon murgoci* and *Icacinoxylon* sp. In the above-mentioned paper, *Pinus* and *Sequoia* genera are mentioned as possible sources of the resin. Recently, more insects belonging to *Hymenoptera, Coleoptera* and *Diptera*, together with pseudoscorpions and pollen spores of *Sequoia* were reported (Neacşu, 2003[26]; Frunzescu & Brănoiu, 2004[27]).

2.1.4. Everlasting Fires of Terca (=*Focul viu de la Terca*)

This is a protected area of IUCN III category (declared by the Law No. 5/2000), located within the territory of Lopătari commune, Terca village (Coordinates: Latitude 45°32'09.5460"N, Longitude 26°32'55.4280"E), with a surface of 0.03 ha. It may be accessed from the county road DJ 203K, going upstream on the Slănicul de Buzău Valley. From Lopătari to Terca, the local infrastructure is precarious: the route follows a 7 km non-asphalted road with a degraded embankment and no road signs. Near „Everlasting fires" the road becomes inaccessible; there are 4 km to be walked by foot.

Geologically, the site is located within Tarcău Nappe, in the Eocene deposits cropping out in the area, in the NW part of the Geopark, on the western slope of Brezău Ridge, at the altitude of

[24] Protescu O. (1937). *Étude géologique et paléontologique de l'ambre roumain. I. Les inclusions organiques dans l'ambre de Buzău.* Bul. Soc. geol. rom., **III**, 65-82, Bucuresti.
[25] Petrescu I., Ghiurca V., Nica V. (1989) *Paleobotanical and palynological researches on the Lower Oligocene amber and amber-bearing formation at Colţi-Buzău*. The Oligocene from the Transylvanian Basin, Cluj-Napoca, p. 183-197.
[26] Neacşu, A. (2003). *Studiul mineralogic, fizico-chimic şi gemologic al chihlimbarului de la Colţi*. PhD Thesis, University of Bucharest.
[27] Frunzescu, D., Brănoiu, Gh. (2004) *Monografia geologică a bazinului râului Buzau*. Ed. Univ. Ploieşti, 458 p.

1030 m. The Everlasting fires is a natural phenomenon caused by the emergence of natural gases, mostly consisting of methane (approximately 80%), the rest being represented by carbon dioxide. The methane comes from great depths of over 1000 m, from Miocene rocks that have a high hydrocarbon content and are highly fractured, allowing the release of gas to the surface. The Everlasting Fires are spread over an area of roughly 100 m^2; the flame heights reach up to 1 m (**Plate 8**).

The Everlasting fires from the Terca area have a variable intensity that fluctuates depending on the gas emissions, which may intensify due to the regional seismic activity (in connection with Vrancea seismic zone) and/or the very active neo-tectonic processes. The vulnerability of this geological protected site is linked to the landslides or earthquakes.

2.1.5. The mineral springs from Fişici (*Izvoarele minerale de la Fişici*)

The occurrence of the mineral springs in the central part of the BLG, around the Fişici locality (Coordinates: Latitude 45°24′13.9″ N; Longitude: 26°27′49.2″ E), is linked to the presence of Oligocene-Lower Miocene bituminous facies of the Kliwa Sandstone, cropping out in the Tarcău Nappe (Melinte-Dobrinescu *et al*., 2016). The mineral springs are reached throughout the National Route DN10 Buzău - Braşov up to the Măgura locality, from where the route passes by Pârscov, Cozieni and Bozioru localities and finally to the Fişici village.

In the Fişici area there are impressive outcrops of Oligocene-Lower Miocene quartzous sandstones, in metric beds, interbedded with bituminous clays, marls and cherts (**Plate 9a**). Due to the high variability of the surrounding rock geochemical composition of the Fişici mineral springs are known to have a great variety of colors, odors and flavors. For instance, the springs with high hydrocarbon content are blackish (**Plate 9A**), the sulphur ones are whitish-pink (**Plate 9B**), while those containing iron are reddish-yellowish (**Plate 9C**). Local people described these springs as ‘living water’ (those lightly colored) and ‘dead water’, referring to the darkish ones. Until 1990, a resort was situated in the village, including a sanatorium and a public bath, but unfortunately now everything is in decay.

Presently, the springs from Fişici have a constant high flow, keeping their hydrodynamic characteristics during the whole year, including drier periods (Melinte-Dobrinescu *et al*., 2017). Unlike other mineral springs of the outer part of the Eastern Carpathian bend, such as those from the Neamț and Bacău counties, i.e., Bălțătești, Slănic Moldova and Târgu-Ocna, the mineral springs of the BLG are not captured, albeit therapeutically they are very important.

2.1.6. The Muncelu Cărămănesc Gypsum (*Gipsul de la Muncelu Cărămănesc*)

A particular evaporite deposition occurring in the BLG is represent by the Lower Miocene (Burdigalian) gypsum, situated towards south of the Fişici locality (**Plate 10a**). It was described as The Muncelu Cărămănesc Gypsum (Ştefănescu *et al*., 1989). The gypsum is interbedded with gray pelites cm-thick (**Plate 10b**) and exposes several folds, some of them "chevron" type. In the area there are chlorosodic mineral springs, while the ones from the neighborhood localities, Fişici, Nucu and Găvanele villages, are mainly sulphurous.

3. THE SUBCARPATHIAN NAPPE

Brief history of the geological-paleontological knowledge. The Miocene and Pliocene deposits of the Subcarpathian Nappe exposed in the BLG territory were intensively studied since the first half of the 20th century (Porn & Murgoci, 1910[28]; Rabischon, 1924[29]; Krejci-Graf & Wenz, 1931[30]; Paucă, 1944[31], among many others), mainly due to the resource potential (hydrocarbons and salt) of this area. Ciocârdel (1943[32]) investigated the Miocene and Pliocene faunas from the oil region Berca-Beciu-Arbănaşi. Filipescu (1940)[33] brought significant contributions in the establishment of the boundary between the regional Eastern Paratethyan stages, such as Sarmatian-Meotian, Meotian-Pontian, Pontian-Dacian and Dacian-Romanian (=Levantin); these deposits are cropping out in the Pănătău and Berca-Arbănaşi regions. Oncescu (1948)[34] made a detailed geological mapping in the region Ruşavăţu - Vf. Pănătău – Pietrari - Sarea lui Buzău, while Olteanu (1951)[35] investigated the "salt breccia" occurring between the Teleajenul and Bălăneasa valleys. The Miocene stratigraphy of the deposits occurring between the Buzău and Motnău valleys was described by Saulea (1956)[36], while the whole Neogene from the Buzău Valley by Stoica (1962)[37].

The Miocene evaporites between the Buzău and Teleajen valleys were studied by Frunzescu (2002)[38]. The oldest geological maps of the territory of the Subcarpathian Nappe comprised within the BLG were published in the 6th decade of the 20th century, i.e., the Covasna Sheet, scale 1:100,000 by Popescu and Mutihac (1960)[39] and the Buzău Sheet, scale 1:100,000, compiled by Dragoş (1959)[40]. Both maps have been published by the Geological Institute of Romania.

Based on the acquired data, two geological maps at the scale 1:200,000 were published by

[28] Porn M., Munteanu-Murgoci Gh. (1910) *Regiunea Policiori-Berca-Beciu-Arbănasi*. Rev. gén. Sc. Appl. (Rev. pétrole), **V**: 335-342, Bucureşti.
[29] Rabischon A. (1924) *Studiu geologic şi petrolifer al regiunii cuprinse între Pătârlagele şi Cislău, judeţul Buzău (zonele petrolifere dela Geroasa-Măguricea-Coculeşti-Tega-Poienii de Jos-Cislău-Olari-Bâscenii de Jos).* Mon. Petr., **XXIII**: 1601-1610, Bucureşti.
[30] Krejci-Graf K., Wenz W. (1931) *Stratigraphie und Paläontologie des Obermiozäns und Pliozäns der Muntenia (Rumänien).* Zeitsch. d. Deutsch. Geol. Ges., **83**/2-3, Berlin.
[31] Paucă M. (1944) *Nouvelles données sur l'anticlinal de Cislău-Punga (départ. de Buzău).* C. R. des Séances, **XXVII**: 45-51, Bucarest.
[32] Ciocârdel R. (1943*) Die pliozäne Faune von Berca-Arbănaşi*. Z. dtsch. geol. Ges., **XCV**: 449-455, Berlin.
[33] Filipescu M.G. (1940) *Étude géologique de la région comprise entre les vallées de Teleajen et du Slănic-Bâsca Mică (Buzău)*. C. R. Inst. Geol. Rom., **XXIII**: 78-100, Bucarest.
[34] Oncescu N. (1948) *Rapport sur levers géologiques effectués dans la région Ruşavăţu-Vf. Pănătău-Pietrari-Sarea lui Buzău, pendant la campagne de travail 1941*. C. R. Inst. Geol., Rom., **XXX**: 80-94, Bucureşti.
[35] Olteanu Fl. (1951) *Obsevaţii asupra "breciei sării" la masivele de sare miocene cuprinse între valea Teleajenului şi valea Bălăneasa, cu privire specială asupra regiunii Pietraru-Buzău*. D. S. Inst. Géol. Rom., **XXXII**: 12-18, Bucureşti.
[36] Saulea E. (1956) Contribuţiuni la stratigrafia Miocenului din Subcarpaţii Munteniei. An. Com. Geol., **XXIX**: 241-270.
[37] Stoica C. (1962) Consideraţii privind stratigrafia Neogenului din valea Buzăului. D.S. Com. Geol., **XLV**: 37-57.
[38] Frunzescu D. (2002) *Miocenul din partea de sud a Carpaţilor Orientali – Megasecvenţe evaporitice.* 233 p., Ed. Univ. Ploieşti.
[39] Popescu G., Mutihac V. (1960). Covasna Sheet, scale 1:100,000. Printed by the Geological Institute of Romania.
[40] Dragoş V. (1959). Buzău Sheet, scale 1:100,000. Printed by the Geological Institute of Romania.

the Geological Institute of Romania: Covasna Sheet (Dumitrescu *et al*., 1968) that covers the main part of BLG and Ploieşti Sheet (Motaş *et al*., 1967), covering also the Subcarpathian Nappe. Detailed geological features of this unit are presented in the Map Sheet Nehoiu scale 1:50,000 made by Ştefănescu *et al*. (1993) and published by the Geological Institute of Romania.

3.1. The Meledic Plateau, including the salt karst (*Platoul Meledic*)

The Meledic Plateau is a protected area of national interest (Law 5/2000), corresponding to the category IV IUCN (mixed geological, speological, botanical and zoological National Reserve), covering 67.50 ha located in the administrative territories of Lopătari and Mânzălești localities. The site is reached following the route in the Slănicul de Buzău Valley DJ 203 K, starting from DN2 (E85) from Mărăcineni towards Săpoca; the route crosses the bridge over the Buzău River and goes through the localities Beceni-Vintilă Vodă-Mânzălești (Coordinates: Latitude 45°29'52.5552" N; Longitude 26°37'11.1396" E). The conservation state is moderate. The vulnerability is linked to the existence of landfalls, landslides, surface erosion, pluvial denudation and erosion by rain-wash and gullying.

Located on Lower Miocene deposits, the Meledic Plateau displays abrupt slopes towards the four cardinal points limiting valleys and also towards Sării, Izvorul Sărat and Grădinii valleys, last two being drained towards the Slănicul de Buzău Valley. The structure of the plateau is visible on the slopes: an upper 10-30 m thick bed of shales and marls overlying salt breccia deposits, which are especially remarked in the salt karst exposed on the left side of the Slănicul de Buzău Valley, at Mânzălești. The Salt Mountain from Mânzălești, whose occurrence is related to the diapirism phenomenon, is the most spectacular landscape of the Meledic Plateau. The escarpment is exposed on about 2.5 km along the Slănic River, upstream from the Mânzălești Village. The salt massif extends 3 km toward N-NE (Mărunțeanu & Ioane, 2010[41]).

Layered gypsum outcrops in riverbeds of the short but deep valleys which furrow the edges of the plateau. The walls and slopes of the Salt Mountain exposes salt micro-ravines with sharp edges and sharp cone shapes, with 2-3 cm base and heights reaching 20 cm (**Plates 11, 12**). Exploration drills showed a medium content of NaCl of 81.7 % (Giurgiu, 2005)[42], the salt being deposited approx. 23 million years ago, within the Early Miocene, i.e., Aquitanian (Dumitrescu *et al*., 1968; Paucă, 1978[43]).

[41] Mărunțeanu C., Ioane D. (2010). *Salt Karst in Mânzălești - Romania*. In: Evelpidou, N., de Figueiredo, T., Mauro, F., Tecim, V., Vassilopoulos, A., (Eds.), Natural Heritage from East to West: Case studies from 6 EU countries. Berlin Heidelberg: Springer& Business Medi, p. 105-110.
[42] Giurgiu I. (2005). *Muntele recordului mondial*. Invitaţie în Carpaţi, Anul 9, nr. **51**, serie nouă: 1-17, Ed. alpinet®.org
[43] Paucă M. (1978). *Evaporitele din România. Aspecte genetice, paleogeografice și tectonice*. Anuarul Muzeului de Științe Naturale din Piatra Neamț, Seria Geologie - Geografie, **IV**: 7-47.

Small valleys are formed on the slopes, with reduced lengths and thalweg with high slope, sometimes even meters deep canyons (Ielenicz, 1985)[44]. In the southern extremity of the plateau, on the right side of the Buzău-Mânzăleşti-Lopătari road, towards Trestioara, specific salt karst features are individualized, such as sinkholes, ditches and ravines, caves located at the end of streams. A number of 45 caves were discovered, having a total length of 4.544 m. Amongst them, there is the Cave 65 from Mânzălești with 3,234 m length and 44 m depth which held the world record for the longest salt cave (Ielenicz, 1985).

3.2. The Sphinx from Buştea (*Sfinxul de la Buştea*)

North of Lopătari (Coordinates: Latitude 45°30'45.2902" N; Longitude 26°35'04.7501" E), at Trestioara locality, on both flanks of Puşcăria anticline, the Lower Miocene (Aquitanian) is represented by gypsum, grey marls and a breccia complex comprised of marls, gypsum with elements of green schist and conglomeratic sandstones lenses attributed to the "Buştea Sandstone" and "Călcâiu Slate" (Grigoraş, 1955). The grey, locally reddish calcareous sandstone is a medium-coarse grained-size, in beds of 40 cm up to 4 m, slightly concretionary, frequently forming specific features. This site is known by both locals and tourists, but is not included in the List of Natural Monuments.

3.3. The White Stone „La Grunj" (*Piatra Albă „La Grunj"*)

The site (Coordinates: Latitude 45°29'23.7300" N; Longitude 26°38'24.0299" E) may be reached by following the road DJ 203 K along the Slănicul de Buzău Valley, which starts from DN2 (E85) from Mărăcineni to Săpoca (before the entrance on the bridge over Buzău), following the route Beceni-Vintilă Vodă. This is a protected site, a Geological nature reserve IUCN Category III, from 1995, located at the confluence of Slănicul de Buzău and Jgheab rivers. The Middle Miocene (i.e., Central Paratethyan stage Badenian) spectacular outcrop is an impressive white stone of 18 m height and 15 m diameter (**Plate 13**), known in the Romanian geological literature as "The Badenian Tuff". To note that the sediments aforementioned capped by the Badenian evaporites in the Eastern Carpathians indicated, based on $^{40}Ar/^{39}Ar$ dating, an age of 13.32 Ma (De Leeuw *et al*., 2018[45]). The protected site is composed of volcanic material (ash) resedimented in a marine environment, which is confirmed by the presence of marine organisms (planktonic foraminifers and calcareous nannofossils), present in thin-stratified pelites. Unlike the "Slănic Tuff", named in the

[44] Ielenicz M. (1985). *Karst et pseudokarst dans les montagnes et les collines subcarpatiques des bassins du Buzău et du Teleajen*. Theoretical and Applied Karstology, **2**: 47-53.
[45] de Leeuw A., Tulbure M., Kuiper K.F., Melinte-Dobrinescu M.C., Stoica M., Krijgsman W. (2018) *New $^{40}Ar/^{39}Ar$, magnetostratigraphic and biostratigraphic constraints on the termination of the Badenian Salinity Crisis: Indications for tectonic improvement of basin interconnectivity in Southern Europe*. Global and Planetary Change, **169**: 1-15.

Slănic Prahova region "Piatra Verde" (The Green Stone), the one from Grunj is white. The site is vulnerable to disaggregation, rain-wash and gullying, pluvial erosion, action of permanent running water, lateral erosion and anthropic destruction.

3.4. Sarmatian coquinas with *Mactra* (*Calcare lumaşelice sarmaţiene cu Mactra*)

Sarmatian (Middle Miocene, upper part) complete successions are cropping out in the BLG area within the flanks of the Ruşavăţ, Pădureni and Sărata-Năieni synclines. The Sarmatian is known to be an interval of significant paleoenvironmental changes (synthesis in Jipa & Olariu, 2013). Hence, in the Lower Sarmatian (Volhynian) a brackish paleoenvironment settled, due to the isolation of the Carpathian bend related to the active tectonics. Towards the end of the Volhynian, a marine setting occurred again, but progressively shifted to a brackish up to fresh-water deposition in the Middle Sarmatian (Bessarabian) and Upper Sarmatian (Khersonian). Therefore, a lithofacies variation took place both in time and space. For instance, in the BLG territory, a calcareous reef facies with bioherm and serpulids developed at Bozioru. The Volhynian crops out on the western flank of the Odăile syncline, and on left bank of the Buzău Valley, close to the Pănătău locality. Numerous coquina variable in size Late Sarmatian (Khersonian) in age occur on Buzău and Slănicul de Buzău valleys; some perfectly preserved molds may be seen (**Plate 14a**), along with *Mactra* tangential sections (**Plate 14b**), gastropods and bivalves (mainly *Mactra*) in a ferruginous cement (**Plate 15**). Towards N of the BLG, on the Râmnicul Sărat Valley, around Jitia de Jos locality, *Mactra* spp. coquinas (including *Mactra caspia* EICHWALD and *M. bulgarica bisocensis* SIM. & BARBU) were described by Brustur *et al*. (2005)[46].

3.5. Rock concretions 'The Old Ladies from Ulmet' (*Babele de la Ulmet*)

"The Old Ladies from Ulmet" (Babele de la Ulmet) are located in central-southern part of the BLG, being characterized by the presence of Middle Miocene (Sarmatian) sandstone concretions (= in Romanian namely 'trovanți'). This site (Coordinates: Latitude 45°23'08.2601" N; Longitude 26°27'51.9502" E) is already included in many tourist routes, being very appreciated by Romanian and foreign tourists, even it is not included yet in the natural protected areas of the region. Ulmet may be reached from Pârscov locality and further towards Cozieni and next up to the village Bozioru; there, in the central part of the village there is a route to the village Ulmet (following the marker *Babele de la Ulmet*). The distance to walk is around 2 km, with the last 200 m climbing on a path, up to the top of the hill.

[46] Brustur T., Jipa D. C., Szobotka St. (2005). *The shelly Sarmatian-beds in the Râmnicu Sarat basin (Jitia de Jos, Vrancea County),* Geo-Eco-Marina, **11**: 67-76.

This site displays spectacular concretions, with various forms occurring on alignments on the crests nearby the Ulmet village. Usually, concretions appear as a hard, compact mass of matter formed by the precipitation of mineral cement within the spaces between particles. The geologists agree that, in general, concretions form subsequent to burial during diagenesis. The word 'concretion' proceeds from Latin, "con" means together, while "cresco" signifies to grow. People often describe the concretions as 'living stones' or 'growing stones'. The concretions frequently form by the precipitation of a considerable amount of cementing material around a nucleus, of an inorganic or organic origin. The formation of the concretions implies the existence of sandy sediments, in addition to the presence of a significant quantity of carbonate fluids.

In Romanian, the concretions are termed '*trovanți*' (sg. *trovant*). This word appeared in the Romanian geology at the beginning of the 19th Century, when Murgoci (1907)[47] described such concretions from the Miocene of Oltenia (SW Romania).

At Ulmet, the concretions occur on the W flank of the syncline Bozioru-Odăile, Middle Miocene (Early Sarmatian in age, respectively Volhynian). Displaying various forms and sizes, some concretions are already detached, while other are embedded in the sandy substratum, being placed on parallel alignments that mark on the topography the NW termination of the syncline. Most concretions are spherical; some of them contain at the base microconglomerates (**Plate 16**). Parallel or cross lamination could be observed in the sandstone beds. It is to assumed that the concretions from Ulmet have formed during early diagenesis processes (syndiagenesis) of the Middle Miocene sediments. Hence, the occurrence of these concretions is linked to the presence of the sandy sediments, in which a high porosity was preserved, along with a variable dispersal of the minerals that locally concentrated; a significant circulation of carbonate fluids in these sandy sediments was also present.

Filipescu (1940[48]) was the first to decipher the structure of the Ulmet region and the surrounding, describing the asymmetrical syncline that developed between the Bâsca Chiojdului Valley and the Odăile Lake. Later, Saulea (1956[49]) described the Middle Miocene (Sarmatian) rocks of the same syncline as having 1200 m stratigraphic thickness. She has separated two distinct successions: (i) the lower one, of around 800 m thick, made by alternating very thick, up to 200 m, sands and clays; (ii) the upper one, 400 m thick, composed of the same alternating sands and clays sequences, but much thinner. The two aforementioned successions are separated by conglomerates. The concretions have been also observed by Saulea (1956) in the lower part of the Sarmatian. Based

[47] Murgoci, G. (1907). *Terţiarul din Oltenia cu privire la sare, petrol şi ape minerale*" [The Tertiary from Oltenia, with special regard to salt, oil and mineral waters]. An. Inst. Geol. Roum., **I**/1, 128 p., Bucuresti.
[48]Filipescu, M.G. (1940). *Étude géologique de la région comprise entre les vallées de Teleajen et du Slănic-Bâsca Mică (Buzău)*. C. R. Inst. Geol. Rom. **XXIII**: 78-100, Bucarest.
[49]Saulea, E. (1956). *Contribuţiuni la stratigrafia miocenului din Subcarpaţii Munteniei*. An. Com. Geol. **XXIX**, 241-270, Bucureşti.

on the lithofacies and macrofaunal content, the Sarmatian deposits from the Ulmet area and its surroundings was divided by Stoica (1960[50]) in 3 successions: (i) lower, made by sands and sandy sandstones with *Cerithium* and common *Ervilia*; (2) middle, mainly marly, containing mollusk taxa, i.e., *Cryptomactra*, *Cardium* and *Tapes*; (iii) upper, with marls and limestones, with *Ervilia* and *Mactra*. From a macropaleontological point of view, the sandstones making *'Babele' (The Old Ladies) from Ulmet* Site contain foraminifers, i.e., *Elphidium macellum* and *E. minutum*, as the other Lower Sarmatian (Volhynian) sediments of the region.

The petrographic analyses of the 'trovanți' (concretions) from Ulmet (made by Assoc. Prof. Dr. Relu Roban, Faculty of Geology and Geophysics, University of Bucharest) indicate that the sediments forming these concretions are lithic sandstones, with a substitution carbonate cement of pores but also basal (mosaic and poikilitic) – **Plate 17**. The grain size varies from one concretion to another, from fine (Mode ~0.125-0.2 mm) to medium (Mode ~0.5-1 mm) sands.

Concerning the avalanche of materials supposing the existence of megaliths, petroglyphs, etc., appeared in the media and various local publications, we mention those said by Marcian Bleahu (in Lazu, 1984)[51] "merely misinform the public and accredit false ideas that they are creations of long-lost civilizations or that they represent objects of worship; such statements with a great deal of public scrutiny are completely unscientific and must be fought firmly".

The site is affected by natural hazards, i.e., frequent rock collapses due to wind erosion as the ridge outcrop is intensively exposed to this type of erosion, along with water erosion (torrents formed during high rainfall and freeze-thaw intervals). Recently, damages produced by some "tourists" were reported. In our opinion, it is mandatory that this site becomes a protected IUCN one.

[50] Stoica, C. (1960). *Consideraţii privind stratigrafia neogenului din valea Buzăului*. Dări de Seamă ale Comitetului Geologic **XLV**: 37-57, Bucureşti.
[51] Lazu I. (1984) *Natura sculptează*. 16 pag., 71 pl., Ed. Sport-Turism, Bucureşti.

4. THE CARPATHIAN FOREDEEP

Brief history of the geological-paleontological knowledge. The outermost (eastern) part of the BLG extends on the Inner Foredeep of the Eastern Carpathians. Detailed geological studies were made by Macarovici (1961)[52] on the Dacian deposits from Berca-Arbănaşi and Pană (1966)[53] who investigated the Pliocene exposed between Buzău and Bălăneasa valleys. Significant contributions on the Miocene and Pliocene stratigraphy were brought by Andreescu (1972[54] and 1982[55]) and Snel *et al*. (2006[56]).

The stratotypes of the Dacian and Romanian stages, both situated in the BLG territory, in the Slănicul de Buzău Valley, were studied by Papaianopol *et al*. (1995[57] and 2003[58]), Andreescu (2008[59]) and Macaleţ *et al*. (2016)[60].

Recently, Andreescu *et al*. (2011)[61] evaluated the Pliocene-Pleistocene boundary. The magnetostratigraphy of the Upper Neogene was published by Rădan & Rădan (1998[62]), Andreescu (2008, 2009[63]) and Van Baak *et al*. (2015)[64]. The influence of Mediterranean sea-level changes (mostly related to the Messinian Crisis) on the depositional history and paleoambiances of the

[52] Macarovici N. (1961). *Observaţii stratigrafice pe structura Berca-Arbănaşi (cu privire specială asupra limitelor Dacianului)*. St. cerc. Geol., **VI**(3): 387-403, Bucureşti.
[53] Pană I. (1966). *Studiul depozitelor pliocene din regiunea cuprinsă între valea Buzău şi valea Bălăneasa*. Stud. tehn.-econ., **J1**: 136 p., Inst. Geol., Bucureşti.
[54] Andreescu I. (1972). *Contribuţii la stratigrafia Dacianului şi Romanianului din zona de curbură a Carpaţilor Orientali*. D. S. Inst. Geol., **LVIII**: 131-156, Bucureşti.
[55] Andreescu I. (1982). *Biocronologia şi cronostratigrafia Pliocenului superior şi Pleistocenului inferior din Bazinul Dacic*. Anal. Univ, Bucureşti, **XXXI**: 56-66.
[56] Snel E., Mărunţeanu M., Macaleţ R., Meulenkamp J.E., van Vugt N. (2006). *Late Miocene to Early Pliocene chronostratigraphic framework for the Dacic Basin, Romania*. Palaeogeography, Palaeoclimatology, Palaeoecology, **238**/1-4: 107-124.
[57] Papaianopol I., Marinescu Fl., Macaleţ R. (1995). *Le stratotype du Dacien de Beceni (la vallée de Slănicul de Buzău)*. In: Papaianopol I. & Marinescu Fl. (Eds.) Chronostratigraphie und Neostratotypen. Neogen der Zentralen Paratethys, Bd. **IX**, Pliozän P_1 Dacien, 103-106 p., Ed. Acad. Rom., Bucureşti.
[58] Papaianopol I., Marinescu F., Macaleţ R. (2003). *Les coupes representatives (stratotypes, faciostratotypes, stratotypes de limite)*. In: Papainopol I., Marinescu Fl., Krstič N., Macaleţ R. (eds.) Chronostratigraphie und Neostratotypen. Pliozän Pl_2 Romanien, 133-173 p., Ed. Acad. Rom., Bucureşti.
[59] Andreescu I. (2008). *Magnetostratigrafia depozitelor sarmato-pliocene din estul Bazinului Dacic*. In: Avram C. & Melinte M.-C. (Eds.) Paleoambianţe şi paleodiversitate în contextual schimbărilor globale, 5-116 p., Ed. Eikon, Cluj-Napoca.
[60] Macaleț, R., Brustur, T., Jipa, D., Briceag, A., Stănescu, I. *Pliocene Stage Stratotypes in the Buzău Land Geopark (Romania)***.** International Multidisciplinary Scientific Geoconference SGEM, Albena, vol. **1**(1): 483-490, ISBN 978-619-7105-55-1, ISSN 1314-2704.
[61] Andreescu I., Codrea V., Enache C., Lubenescu V., Munteanu T., Petculescu A., Ştiucă E., Terzea E. (2011). *Reassessment of the Pliocene/Pleistocene (Neogene/Quaternary) boundary in the Dacian Basin (Eastern Paratethys), Romania.* Muzeul Olteniei Craiova. Oltenia. Stud. Com. St. nat., **27**/1: 197-220.
[62] Rădan C.C., Rădan M. (1998) .*Study of the geomagnetic field structure in the Tartiary in the context of magnetostratigraphic scale elaboration. I. The Pliocene*. An. Inst. Geol. Rom., **70**: 215-231.
[63] Andreescu I. (2009*). Magnetostratigraphy of the Upper Neogene deposits in the Eastern Dacian Basin: an overview.* Muzeul Olteniei Craiova. Oltenia. Stud. Com. St. nat., **XXV**: 329-336.
[64]Van Baak Ch.G.C., Mandic O., Lazăr I., Stoica M., Krijsman W. (2015). *The Slanicul de Buzau section, a unit stratotype for the Romanian stage of the Dacian Basin (Plio-Pleistocene, Eastern Paratethys)*. Palaeogeography, Palaeoclimatology, Palaeoecology, **440**: 594-613.

Dacian Basin partly included in the BLG area were published by Clauzon *et al*., (2005)[65]; Jipa (2005)[66]; Leever *et al*. (2010)[67]; Krijgsman *et al*. (2010)[68] and Stoica *et al*. (2012)[69].

One of the first paleontological studies in the region belongs to Wenz (1942)[70]. Later, a detailed biostratigraphy, mainly made on mollusk taxa, were performed by Pană, 1968[71]; Motaş, 1971[72]; Andreescu, 1977[73]; Papaianopol, 1975[74], 1977a[75], 1977b[76], 1978a[77]; 1978b[78] and 1987[79] and Papaianopol & Popescu, 1986[80].

Taxonomic studies were published by Lubenescu, 1982[81] and Lubenescu & Zazuleac, 1984[82] along with paleobioecological investigations (Pană 1966, 1968), regarding the evolution of the Neogene faunas of mollusks (Papaianopol & Lubenescu, 1988)[83] and calcareous nannoplankton biostratigraphy (Mărunțeanu & Papaianopol, 1998[84]). In this area, several unpublished PhD Thesis were accomplished, such as Dragoş (1970)[85], Florea (1970)[86], Macaleţ (1997)[87] and Munteanu (1998)[88]

[65] Clauzon G., Suc J.-P., Popescu S.-M., Mărunţeanu M., Rubino J.-L., Marinescu Fl., Melinte M.C. (2005). *Influence of Mediterranean sea-level changes on the Dacic Basin (Eastern Paratethys) during the late Neogene: the Mediterranean Lago Mare facies deciphered.* Basin Research, **17**: 437-462.

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[67] Leever K.A., Matenco L., Rabagia T., Cloetingh S., Krijsman W., Stoica M. (2010). *Messinian sea level fall in the Dacic Basin (Eastern Paratethys): palaeogeographical implications from seismic sequence stratigraphy*. Terra Nova, **22**: 12-17

[68] Krijgsman W., Stoica M., Vasiliev I., Popov V.V. (2010) *Rise and fall of the Paratethys Sea during the Messinian Salinity Crisis*. Earth and Planerary Science Letters, **290**: 183-191.

[69] Stoica M., Lazăr I., Krijsman W., Vasiliev I., Jipa D., Floroiu A. (2012). *Paleoenvironmental evolution of the East Carpathian foredeep during the late Miocene-early Pliocene (Dacian Basin; Romania)*. Global and Planetary Change, **103**: 135-148.

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[71] Pana I. (1968) *Espèces du genre Paradacna dans les dépôts pliocènes de la courbure des Carpathes*. Trav. Mus. Hist. Nat. "Gr. Antipa", **VIII**: 573-579.

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[74] Papaianopol I. (1975). *Studiul unor taxoni ai genului Chartoconcha Andrussow din Pliocenul Bazinului Dacic şi importanţa lor biostratigrafică*. D.S. Inst. Geol. Geofiz., **LXI**: 125-148.

[75] Papaianopol I. (1977a). *Plagiodacnele din Bazinul Dacic*. D.S. Inst. Geol. Geofiz., **LXIII**: 35-62.

[76] Papaianopol I. (1977b). *Contributions à l'ètude des prosodacnes du Bassin Dacique*. D.S. Inst. Geol. Geofiz., L**XIII**: 17-33.

[77] Papaianopol I. (1978). *Caladacnele din Bazinul Dacic*. St. cerc. geol., geofiz., geogr., geologie, **23**/1: 133-142.

[78] Papaianopol I. (1978). *Volume et position stratigraphique de quelques taxons du sous-genre Psilodon Cobalcescu*. D. S. Inst. Geol. Geof., **LXIV**: 265-276.

[79] Papaianopol I. (1987). *Contributions à l'ètude du genre Zamphiridacna (Limnocardiidae, Stylodacninae)*. D.S. Inst. Geol. Geof., **72-73/**3: 109-122.

[80] Papaianopol V., Popescu A. (1986). *Variabilité morphologique d'une population de Stylodacna heberti (Cobalcescu)*. D.S. Inst. Geol. Geof., **70-71/**3: 89-102.

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[86] Florea M.N. (1970). *Studiul terenurilor sedimentare din zona Vipereşti-Cislău, Valea Buzăului în vederea realizării unui lac de acumulare*. Univ. Bucureşti.

[87] Macaleţ R. (1997). *Studiul lito-biostratigrafic al formaţiunilor ponţiene de molasă dintre valea Buzăului şi valea Dâmboviţei*. Rezumatul tezei de doctorat, 26 p., Univ. "Al.I.Cuza", Iaşi.

[88] Munteanu E. (1998). *Studiul faunei sarmaţiene din regiunea cuprinsă între valea Lopatna şi valea Buzăului*. Rezumatul tezei de doctorat, Univ. "Al.I.Cuza", Iaşi.

4.1. The Limestone Blocks from Bădila *(Blocurile de calcar de la Bădila*)

The Limestone Blocks from Bădila (Coordinates: Latitude 45°14' 37.00" N; Longitude 26°29'59.00" E) represent a protected area of national interest corresponding to the IUCN category III (Geological and Paleontological Nature Reserve, located in the Buzău County). It was declared a protected area by the Law No.5 of March 6, 2000 (the approval of the National Landscaping - Section III - Protected Areas).

The access is by passing the Pârscov locality from which the route is towards Ruşavăț. This route passes throughout the Bădila village, from where the distance up to this site is around 3 km on a modernized route, except the last 1.5 km. In fact, this protected area is located very close to the **Sarea lui Buzău** (*The Buzău's Salt*) Natural Reserve, up to 1 km towards W.

The protected area includes 3.02 hectares. The m-thick conglomerate blocks with elements of green schists and limestones outcrop on the left bank of Buzau riverbed (**Plate 18A**), which may be reached by crossing the railway; this natural reserve area is known locally as 'La Surduci'. Here, around 40 rocky blocks (different sizes and shapes) are displayed (**Plate 19a**); they consist of limestone and conglomerate blocks, the former dating from the Mesozoic times (Jurassic). In the Jurassic rocks, several macrofossils, such as gastropods (snails), corals, ammonites (mollusks) and also microfossils, i.e., foraminifers and radiolarians, are present.

The site is located, from tectonic point of view, in the Foredeep of the Eastern Carpathians, a unit characterized by the large outcrops of Middle to Upper Miocene deposits - Bleahu *et al.* (1977)[89]. *Blocurile de calcar de la Bădila* (= The Limestone Blocks from Bădila) represents a very unusual occurrence, being located in an area where there are no massive limestones *in situ* or in the basement of which could have originated. This fact is surprising, because limestone formations have a different age than the surrounding area, the latter being much younger (Neogene), while the limestones are Late Jurassic (Tithonian) in age. The limestone blocks show significant size variations, from 1 m^3 to 400 m^3; probably the whole mass of limestone must reach a volume of 10,000 m^3. Recently, Popa *et al.* (2016)[90], by using UAV mapping, identified 426 limestone blocks, from which 12 are between 4-20 m, the rest of 414 being smaller, between 0.1 and 4 m. As in other areas of the S Eastern Carpathians (i.e., the Adânca Valley, according to Protescu, 1928[91]), where huge Jurassic blocks occurred, the outcrops surrounding these blocks are represented by the Middle Miocene (Badenian) salt breccia.

We assume that the occurrence of Jurassic limestone blocks is linked to the salt diapirisim

[89] Bleahu M., Brădescu Vl., Marinescu F. (1977) *Rezervaţii naturale geologice din România*. Ed. tehnică Bucureşti, 224 pp.
[90] Popa A., Jipa D.C., Rădan S., Melinte-Dobrinescu M.C., Brustur T., (2016) *Salt diapir exotic blocks from Bădila Nature Reserve (Buzău Land Geopark, Romania). A drone-based textural evaluation*. GeoEcoMarina, **22**: 119-134.
[91] Protescu, O. (1928). *Structure géologique des Subcarpates dans la partie méridionale du district de Buzău*. Inst. Geol. Roum.,Comptes Rendues des Séances **8**: 152-174.

phenomenon, widespread in the region. Along with huge Jurassic blocks, conglomerate blocks occurred; these conglomerates contain Oligocene and Miocene rocks, as well as numerous fragments of green schists, typical for the basement of the East European Platform, located towards E in respect with the Eastern Carpathian chain. Such clasts of green schists are present in Oligocene and Miocene sediments, while the youngest level where they could be found is Lower Miocene (Burdigalian). This fact argues that the diapirisim present in the region is post-Burdigalian, most probably Middle Miocene (Badenian). Frunzescu & Brănoiu (2004)[92] assumed that the salt breccia from Bădila (termed by them *Cosmina Breccia*) belongs to the faulted W flank of the anticline Lapoş-Bădila-Pietraru, located in the Carpathian Foredeep of Carpathian Bend. The salt breccia (**Plate 18B**) shows a stratigraphic thickness between 150-200 m and has a discordant and transgressive contact with the underlying formations. The components of the salt breccia are heterogeneous in terms of grain-size, predominantly fine to medium rudites, while the dominant elements are mainly sub-angular and less sub-rounded.

The paleontological content that is protected in the Geological and Paleontological Reserve refers exclusively to the fossils of the Jurassic reefal limestones, which frequently contain corals, plates and spines of echinoderms, brachiopods, mollusk fragments (such as *Nerina* and *Perisphinctes*) and red algal nodules. Microfaunal content is represented by foraminifera (i.e., *Miliolida*, *Textularia* and *Rotalia*), calcified radiolarians (*Spumellaria* and *Nasselaria* genera), ostracods and bryozoans. Interesting is the occurrence of fragments of calpionellids that are ciliated marine organisms; the encountered taxa belong to the species *Calpionella alpine* that has the range within the latest Jurassic (late Tithonian) – earliest Cretaceous (Berriasian) interval.

This age is substantiated by the presence of cephalopod (ammonite) species of the genus *Perisphinctes* (**Plate 19b**). The facies of the Jurassic limestone blocks including their litho- and microfacies were detailed analyzed by Filipescu (1938[93]) and Pană & Nimigean (1982)[94].

This site may be damaged by the action of permanent running water, lateral and bottom erosion and/or alluviation.

4.2. The Buzău's salt (*Sarea lui Buzău*)

This Nature Reserve (Coordinates: Latitude 45°14′59.79″ N; Longitude 26°29′58.70″ E) was declared a protected area by Law No. 5 of 6 March 2000 (No. 2.263), being included in the list of natural monuments in Romania since 1955. The Buzău's Salt is a protected area of national

[92] Frunzescu, D., Brănoiu, Gh. (2004,). *Monografia geologicã a bazinului râului Buzău*. Ed. Univ. Ploieşti, 458 pp.
[93] Filipescu, M.G. (1938). *Le calcaire de Bădila (Buzău) et quelques considérations sur l'enveloppe du sel*. Comptes Rendues Séances **XXII**: 4-8.
[94] Pană. D., Nimigean, D. (1982). *Calcarul de la Bădila – monument geologic (jud. Buzau).* Monumente geologice din Romania, Volum special, Univ. Bucureşti, p. 51-62.

interest corresponding to IUCN category III (geological and botanical natural reserve) located on the administrative territory of Vipereşti commune, with an area of 1.77 ha. The Nature Reserve includes a surface with salt springs (**Plate 20**), salt efflorescence area that prove the existence of an underground salt dome, most likely Middle Miocene (Badenian). The Buzău's salt is located in the vicinity of the aforementioned site; thus, the Limestone Blocks from Bădila are located at around 1 km E from The Buzău's Salt.

From the floral point of view, several halophilic plant species are found in the area of the Natural Reserve. The floras include the bush species known in Romanian as 'Cătina de râu' (English: Buckthorn Shrub River, in Latin *Hippophae rhamnoides*) and an herbaceous species *Puccinellia distans* (in Romanian 'Bălănică').

4.3. Mud volcanoes from Bădila (*Vulcanii noroioşi de la Bădila*)

Just before to reach Sarea lui Buzău (*The Buzău's Salt*) natural reserve, on the right, up to the highland, towards the Forest Guard House (Coordinates: Latitude 45°14′56″ N; Longitude 26°29′30″ E), a few structures of mud volcanoes could be seen (**Plate 21**). This is a new mud volcano occurrence; it is not a protected area, being known so far only by local people. The volcano has a small size, up to 20 cm, being much smaller than those of the well-known Berca structures, which are meters high. Around these newly emerged structures, some halophilic plants are present, as salty water reaches the surfaces throughout the fractures. Rock fragments, mostly Miocene, some of them containing coquinas typical for the Middle Miocene (i.e., regional stage Sarmatian) are spread around these small muddy structures.

4.4. Erosion witnesses: "The Whale" and "The lioness and the buffalo" from Sârbeşti

(Martori de eroziune: „Balena" şi „Leoaica cu bivolul" de la Sârbeşti)

At the Sârbeşti village, in the right slope of Slănicul de Buzău Valley (Coordinates: Latitude 45°28′44.90″ N; Longitude 26°41′28.33″ E) there are two erosion witnesses: a metric sandstone block with convex laminae, resembling to a head of a whale (in Romanian „Balena") and another massive sandstone, *in situ*, shaped by the fluvial erosion in the form of a lioness with its head supported on a buffalo skull (Coordinates: Latitude 45°28′35.99″ N; Longitude 26°41′29.64″ E). These shapes in stone are games of nature produced by selective erosion; they can "ignite" popular imagination (**Plate 22**).

4.5. Meotian fossil macrofaunas (*Macrofauna fosilă din Meotian*)

In the BLG territory, the Miocene and Pliocene sediments contain many macrofaunas (especially mollusks), very well preserved. A good example is the Meotian fauna (Coordinates: Latitude 45°29′0.05″ N; Longitude 26°40′20″E) mainly composed of bivalves, such as *Congeria* (*Andrusoviconcha*) *navicula* ANDRUSOV (**Plate 23a1**) and *Congeria* (*Andrusoviconcha*) *novorossica* SINZOW (**Plate 23a2 and 23b2**), Late Meotian in age (Moldavian substage).

4.6. Pontian fossil macrofaunas (*Macrofauna fosilă din Pontian*)

At Sârbești, in the Slănicului de Buzău Valley (Coordinates: Latitude 45°28′59.9″ N; Longitude 26°40′21.3″E), the Lower Pontian (Odessian substage) contains limestone concretions (**Plate 24a**) with *Paradacna abichi* HÖRNES ((**Plate 24b1, 24b2**), *Paradacna radiata* STEFANOVIČ (**Plate 24b3**), *Congeria* (*Rhombocongeria*) cf. *rumana* SABBA (**Plate 24c**) and *Dreissena simplex* BARBOT (**Plate 24d**).

The Middle Pontian (Portaferrian substage) contains rich and well-preserved macrofaunas, with *Congeria* (*Rhombocongeria) rhomboidea* HÖRNES (**Plate 25a, b**), *Paradacna omivaga* PAPAIANOPOL, *Luxuridacna magna* PAPAIANOPOL (**Plate 25c**), *Valenciennius* sp. (**Plate 25e**).

The Upper Pontian (Bosphorian substage) in the Dogari village is very rich in fossils and contains mollusks such as *Valenciennius* sp. (**Plate 26a**), *Pseudocatillus simplex* (FUCHS) (**Plate 26b1**), *Caladacna steidachneri* (BRUSINA) (**Plate 26b2; 26d2,3,5**), *Stylodacna heberti* (COBALCESCU) (**Plate 26c2, 26e**), *Pseudoprosodacna littoralis* (EICHWALD) (**Plate 26c1**), and *Pontalmyra* (*Pontalmyra*) *sabbae* PAPAIANOPOL (**Plate 26d4**).

4.7. Possible Middle Pontian avian and mammalian trace fossils (*Posibile urme de păsări şi mamifere din Pontianul mediu*)

On a sandstone block found at Sârbeşti (Coordinates: Latitude 45°28′55.6″ N; Longitude 26°40′35.4″E), the presence of a bird feeding traces associated with undertracks of a small mammalian (**Plate 27a**), probably similar to the European mink (*Mustela lutreola*) (Plate 27b) were recently described (*Mustela lutreola*) (**Plate 27b**) were recently described (Brustur & Jipa, 2019)[95]. This finding indicates the existence, unknown so far, of terrestrial faunas in the Middle Pontian deposits of the Dacian Basin. This finding indicates the existence, unknown so far, of terrestrial faunas in the Middle Pontian deposits of the Dacian Basin.

[95] Brustur T., Jipa D.C. (2019). *Possible Middle Pontian avian and mammalian trace fossils from the Dacian Basin (Slănicul de Buzău Valley*, *Romania)*. Geo-Eco-Marina, **25**: 193-202.

4.8. Hurricane prod-cast *(Urmă de impact de furtună)*

In the lower part of the Middle Pontian (Portaferrian substage) at Sârbeşti (Coordinates: Latitude 45°28′58.45″ N; Longitude 26°40′24.58″E) the mold of the sedimentary structure related to the object impact shows, on a pelitic bed, the presence of a semiconical depression, ending with a sharp apex (**Plate 28a**). Flattened lobes, with different lengths, are placed perpendicularly on the depression axis, at various distances. These lobes mark the bilateral expulsion of the mud, after the initial impact of the wind transported object (**Plate 28b**). The occurrence of these lobes with various shapes, dimensions and orientations, linked to the depression created after the object impact is indicative for the hurricane paleowind activity in Upper Miocene times (Brustur, 2016)[96].

4.9. Rhizolithes (*Rizolite – Rădăcini fosile*)

The term rhizolithe was defined by Klappa (1980, in Kraus & Eginotis, 2006[97]) as organo-sedimentary structures that preserve the activity of the roots of higher plants. Klappa (1980, in Owen *et al*., 2008[98].) distinguishes 5 types of rhizolithes:

a) root molds – hollow tubes resulting from root drying;

b) root casts – molding resulting from cementing or lithifying the detrital material;

c) root tubules – cement cylinder around the root of the mold;

d) rhizocretions – mineral accumulation around the root of pedogenetic origin;

e) root petrifactions – organic material for cell tissue replacement or impregnation.

Therefore, these structures reflect the plant activity in the Middle Pontian paleosol at Sârbeşti, as described by Brustur & Jipa (2009) (Coordinates: Latitude 45°28′44.80″ N; Longitude 26°41′29.55″E). There, the presence of the friable sandstone with rhizolithes are indicative for the edge of the sedimentary basin paleoenvironment, influenced by hydrostatic oscillations (**Plate 29a**).

The presence in the BLG area of hard-compact rhizolithes that are in general blackish probably due to the Mn oxides may indicate the existence of Pontian siltic soils (**Plate 29b**). By contrast, the clayey grey greenish rhizolites with a red halo are characteristic for the heavily drained paleosoils (**Plate 29c**). The presence of these pedoturbations indicates the colonization with grassy vegetation and shrubs of the marginal lacustrine paleoenvironment, under the conditions of a local and/or regional regression.

[96] Brustur T. (2016). *The hurricane-prod cast: a terrestrial mecanogliph from the Middle Pontian of the Dacian Basin (Slănicul de Buzău Valley, Romania).* Geo-Eco-Marina, **22**: 151-159.
[97] Kraus M.J., Hasiotis S.T. (2006). *Significance of different modes of rhizolith preservation to interpreting paleoenvironmental and paleohydrologic settings: examples from Paleogene paleosols, Bighorn Basin, Wyoming, USA*. Journ. Sedim. Res., **76**: 633-646.
[98] Owen R.A., Owen R.B., Renaut R.W., Scott J.J., Jones B., Ashley G.M. (2008). *Mineralogy and origin of rhizoliths on the margins of saline alkaline Lake Bogoria, Kenya Rift Valley*. Sediment. Geol., **203**: 143-163.

4.10. Other sedimentary structures (*Alte structuri sedimentare*)

Pontian successions of the western flank of the Berca-Arbănaşi anticline cropping out at Sârbeşti (Coordinates: Latitude 45°28′35.69″ N; Longitude 26°41′35.97″ E) frequently contain sedimentary successions made by wave symmetrical oscillations, at the top of a sandy bed covered by a clayey bed (**Plate 30a**), along with current asymmetrical traces (**Plate 30b**). Rarely, erosional contacts at the base of the fluvial channels (**Plate 31a**) may be seen, along with some synsedimentary structures made by landslides or land piercing (**Plate 31b**). Trace fossils of *Ophiomorpha* type were observed on thin cm up to dm calcareous sandstones (**Plate 31c**).

4.11. Pliocene and Pleistocene stratotypes and associated fossil faunas

On the territory of the Buzau Land Geopark several stratotypes of some Pliocene and Pleistocene stages and substages of the Eastern Paratethyan stages are exposed (**Plate 32 down**), along with very rich macrofaunas, mainly made by bivalves and gastropods. The Pliocene and Pleistocene deposits of this area belong to the Dacian Basin (**Plate 32 up**) that extended those times over the Foreland of the Southern and Eastern Carpathians (Jipa & Olariu, 2009).

4.11.1. The stratotype of the Dacian Stage

The holostratotype of the Dacian stage, i.e., the Pontian/Dacian boundary is situated in the BLG, on the Slănicul de Buzau Valley, in the Dogari village (included in the administrative territory of the Beceni commune). The access to this site is from the county route DJ203K Săpoca-Lopătari (Coordinates: Latitude 45°24’34.9” N; Longitude 26°45’29.8” E).

Lithologically, in the exposed site the Upper Pontian is mainly composed of grey, greenish and yellowish clays, interbedded with thin cm sandstones that became more numerous and thicker towards the top of the Pontian. The lithology yielded no marked change within the Lower Dacian. In the Slănicul de Buzău Valley, the Dacian is 500 m-thick (**Plate 33**). At the end of the Late Pontian the genera *Lunadacna*, *Luxuridacna* and *Pteradacna* disappeared. Some other mollusks, commonly encountered in the Upper Pontian substage (i.e., the Bosphorian), such as *Phyllocardium planum* (DESHAYES), *Plagiodacna carinata* (DESHAYES), *Caladacna steindachneri* (BRUSINA) and *Dressenomya* (*Sinucongeria*) *aperta* (DESHAYES), survive in the Early Dacian (Getian substage); notably the genera *Phyllocardium* and *Dreissenomya* are present also in the Upper Dacian (Parscovian substage).

Among other taxa, the base of the Dacian (= the lower part of the Getian substage) comprises rich mollusk macrofaunas, including new taxa of *Prosodacna*, *Zamphiridacna* and

Dacicardium. The upper part of the Getian substage is dominated by taxa belonging to the genera *Pachydacna*, *Chartoconcha*, *Pontalmyra*, *Limnodacna* and *Melanopsis*. The Upper Dacian, i.e., the Parscovian substage, more pelitic as the older Getian substage, commonly contains from the base *Prosodacna (Psilodon) haueri* COBALCESCU, *Stylodacna heberti* (COBALCESCU) and *Viviparus rumanus* (TOURNOUER), while towards its top *Prosodacna (Psilodon) conversus* PAPAIANOPOL, *Limnodacna rumana* PAPAIANOPOL and MOTAS, *Dacicardium rumanum* (FONTANNES) and *Viviparus heberti* COBALCESCU occur.

In the silty succession macrofaunal associations composed of the mollusk taxa *Pontalmyra, Pseudocatillus* and *Chartoconcha,* Late Pontian (Bosphorian substage) in age, may be seen. Above, the sandstone beds contain the following fossils: *Stylodacna, Psilodon, Dacicardim, Dreissena, Chartoconcha, Phyllocardium, Parapachydacna,* indicative for the base of the Dacian stage (Getian substage), overlain by red and gray clays containing *Dreissena, Pachydacna (Parapachydacna) mirabilis* (Teisseyre), *Zamphiridacna orientalis* Sabba, *Pseudocatillus* and *Dacicardium* (Macaleț *et a*l., 2016[99]). Like the other Neogene fossil sites from the Geopark, this site is not protected. Its designation as a natural reserve is necessary, having the uniqueness of microfaunal assemblages and the fact that is the Dacian stratotype of the Eastern Paratethyan domain. The pelitic sequences contain numerous specimens of *Prosodacna* (*Psilodon*) aff. *stefanescui* TOURNOUËR (**Plate 34a**) and *Dacicardium dacicus* PAPAIANOPOL (**Plate 34b, c**). Heavily cemented calcareous sandstone shows internal sections of limnocardids (**Plate 34d1**), tangential sections of *Viviparus* sp. (**Plate 34 d2**, **f1 and f2**), *Teodoxus* sp. (**Plate 34e1**) and internal molds of *Dreissena* sp. (**Plate 34e2**).

4.11.2 The Upper Dacian site from Câmpulungeanca

In the Câmpulungeanca Valley (right tributary of the Slănicul de Buzău Valley), a significant outcrop of the Upper Dacian (Parscovian substage) deposits occurs. The access is from the County Route DJ203K towards the Dogari village and further to the Câmpulungeanca village (Mărgăriteşti commune) on the route 203A (Coordinates: Latitude 45º25’46.3” N; Longitude 26º45’59.9” E). From the lithological point of view, the site is characterized by the presence of sandy yellowish sandstones, containing frequently coquina levels and gray silty cm beds. Upstream, cm up to dm coal levels are present. In this site, several macrofossils, such as mollusks, may be seen. Significant macrofaunal events recorded at the base of the Upper Dacian (= Parscovian) are the first occurrences of the bivalves *Zamphiridacna zamphiri* COBALCESCU and *Prosodacna* (*Psilodon*) *stefanescui euphrosinae* COBALCESCU. These taxa occur only in the Upper Dacian. Additionally,

[99] Macaleț R., Brustur T., Jipa D., Briceag A., Stănescu I. (2016). *Pliocene Stage Stratotypes in the Buzău Land Geopark (Romania)*. International Multidisciplinary Scientific Geoconference SGEM, Albena, **1**/1: 483-490.

both species show an increased frequency before their extinction, forming coquina beds; such an event was remarked not only in the Slănicul de Buzău section, but also in other sections comprising the Dacian/Romanian boundary, such as Gura Dimienii and Câmpulungeanca, both localities situated in the Geopark (Macaleț *et al*., 2016)

The macrofaunas contain: gastropods (mainly *Viviparus* taxa) and bivalves, i.e., commonly *Zamphiridacna zamphiri* and *Prosodacna euphrosinae*, *Dacicardium* spp., *Limnocardium* spp. and *Stylodacna* spp. In the massive sandstones (**Plate 34c**), molds of *Viviparus* taxa along with *Pseudocatillus moesicus* PAPAIANOPOL & LUBENESCU (**Plate 34c1**) were observed, along with *Prosodacna* (*Psilodon*) sp. (**Plate 34c2**), *Zamphiridacna* cf. *suspecta* PAPAIANOPOL (**Plate 34c3**) and ?*Dacicardium* sp. (**Plate 34c4**).

4.11.3. The Holostratotype of the Romanian stage at Valea Părului

This site is located on the territory of the Beceni commune (Coordinates Latitude 45º22’0.07” N; Longitude 26º46’4.5” E). It represents the holostratotype of the Romanian (Macarovici, 1961; Andreescu, 1983; Papaianopol *et al*., 2003) and situated on the Muchia Plopului Hill, in Valea Părului village. According to the aforementioned authors, the boundary between the Dacian and the Romanian stages was defined based on changes in the mollusk assemblages, such as the mass extinction of the *Limnocardium* genus at the boundary between these stages, indicating a lowering salinity of the basin. Above the above-mentioned extinction, the appearance of some flat unionids and new gastropod taxa point out the base of the Romanian stage.

There, the uppermost Dacian (Parscovian substage) contains, among other mollusks, *Prosodacna (Psilodon) euphrosinae* COBALCESCU and *Prosodacna* (*Psilodon*) *haueri arioni* COBALCESCU (**Plate 35A**), followed by 8.9 m of yellowish unfossiliferous clays and 5.3 m of sands and clays with thin cm bentonite levels, ending with a 0.4 m bed of hard sandstones. The latest Dacian age is argued by the presence, in the 5.3 m of sands and clays, of the taxa *Bulimus* (*Tylopoma*) *speciosus* COBALCESCU, *Melanospsis esperioides* SABBA, *Gyraulus* aff. *rumanus* WENZ and *Lithoglyphus decipiensis* BRUSINA. The uppermost Dacian succession is followed by a 0.5 m-thick lignite bed, followed by 12 m of rich fossiliferous sands, containing *Jazkoa sturdzae* (COBALCESCU), *Psilunio slanicensis* (TEISSEYRE), *Potamoscapha* aff. *P. krejcii* (WENZ), *Dreissena polymorpha* PALLAS, *Viviparus bifarcinatus* (BIELZ), *Bulimus croaticus* BRUSINA, *Bulimus oncophorus* (BRUSINA) and *Melanopsis* (*Lyrcaea*) *onusta* SABBA. This succession is followed by another lignite bed of 0.5 m, covered by sandy clays of 7.3 m in thickness, that contain the gastropod species *Theodoxus slavonicus* (BRUSINA) and *Theodoxus scriptus* SABBA. The taxa of the

genus *Unio* did not occur in oldest 20 m above the base of the Romanian (Papaianopol *et al*., 2003; Macaleţ *et al*., 2016).

4.11.4. The Parastratotype of the Romanian stage from Scheiu

The access is from the county road DJ203K Săpoca-Lopătari, Scheiu village (Niculeşti), to the south of the old elderly hospital. The boundary between the Dacian and Romanian stages (Coordinates: Latitude 45°27'10.2" N; Longitude 26°44'44.3" E) are exposed on both banks of the Slănicul de Buzau River (**Plate 36**). There, at the top of the Dacian stage (Parscovian substage), in the sandy deposits comprising rare intercalations of sandstones and clays, a rich mollusk fauna is present (**Plate 35B**). The assemblage contains mainly *Prosodacna (Psilodon) euphosinae* COBALCESCU, *Zamphiridacna zamphiri* (COBALCESCU), *Dacicardium rumanum* (FONTANNES), *Viviparus heberti* COBALCESCU, and *Dacicardium valahicus* PAPAPANOPOL. The Lower Romanian (Siensian) deposits start with sands, sometimes consolidated, and silt with 7-8 intercalations of thin coal. The mollusk fauna from the basal part of the Romanian deposits includes *Jazkoa sturdzae* (COBALCESCU), *Viviparus bifarcinatus* (BIELZ), *Psilunio (Psilunio) slanicensis* (TEISSEYRE) and also many other mollusk fragments present especially in the coal layers (**Plate 37**).

The Dacian grey sandstones contain rarely *Zamphiridacna* taxa – tangential sections (**Plate 38a1**), molds (**Plate 38c**), *Limnocardium* taxa – tangential sections (**Plate 38e**), inner molds, spire fragments and apical sections of *Viviparus* spp. (**Plate 38a2, d1, f**), along with fragments of *Pachydacna* sp. (**Plate 38d2**). Commonly, tangential sections of *Viviparus* may be seen (**Plate 38a2, b**), as well as *Limnocardium* (*Tauricardium*) sp. (**Plate 38c, d**) and *Prosodacna* (*Psilodon*) aff. *haueri* COBALCESCU (**Plate 38e1,2**).

4.12. The secondary gypsum at Beceni

Secondary gypsum rocks, formed from anhydrite by the action of ground waters and/or surface weathering and unmodified by tectonic influences (Holliday, 1970[100]). East from Beceni locality (Coordinates: Latitude 45°22'51.2616" N; Longitude 26°46'27.6240" E), on the Vacii Brook (**Plate 39a**) secondary gypsum, formed from anhydrite occurs. There, the Upper Pliocene deposits (belonging to the regional stage Romanian) are composed of a succession of yellowish sands interlayered with gray-blackish clays (**Plate 39b**), containing numerous gypsum crystals, largely crystallized (**Plate 39c**). Few clays and coal lenses preserved fragments of carbonized plants (**Plate 39d**).

[100] Holliday, D.W. (1970). *The petrology of secondary gypsum rocks; a review*. Journal of Sedimentary Research, **40/**2: 734–744.

4.12.1. The Upper Pliocene-Lower Pleistocene Cândeşti Formation

The Cândeşti Formation (= Cândeşti Beds, Mrazec & Teisseyre, 1901[101]) consists of tens up to several hundred meters alluvial deposits. This unit accumulated in a waste system of alluvial fans, made by gravels, sands and silts. The stratotype of this formation is situated south of the Buzău Valley (Coordinates: Latitude 45°15'41.5692" N; Longitude 26°43'12.4104" E). The lower part of the unit is made by fine gravels and sands (**Plate 40a**), interlayered with m-thick silts and sands showing crossed-bending (**Plate 40b**).

Towards the upper part of the unit, coarse gravels with cm up to dm silt intercalations occur. The Cândeşti Formation encloses rich fossil faunas of mammals and mollusks that indicate a Late Pliocene (Romanian) to Early Pleistocene age.

[101] Mrazec L., Teisseyre W. (1901). *Über Oligozäne Klippen am Rande der Karpathen bei Bacău (Moldau).* Jahrbuch d. k. k. geol. R. A., **51**: 235-246, Wien.

5. Quaternary

5.1. Loess deposits

In the Buzău Land Geopark, the loess deposits (**Plate 41a**) occur in the eastern part (Jipa, 2014[102]), and generally cover the terrace deposits (**Plate 41a1**). Between Berca and Săpoca the loess deposits form vertical slopes of upper terraces situated on the banks of the Buzău Valley. This type of deposits is well developed along the Slănicul de Buzău Valley, especially close to its confluence with the Buzău River. Towards NW Pleşcoi, along Muscelu Brook (Coordinates: Latitude 45°16'31.9908" N; Longitude 26°42'28.1736" E), up to its confluence (**Plate 41b)** the above described deposits and the thick slope deluge completely cover the Pleşcoi Formation (= *Limnocardium* beds, as described by Ciocârdel, 1949; Pană *et al*., 1968[103]; Liteanu *et al*., 1971).

[102] Jipa D.C. (2014). *The conceptual sedimentary model of the Lower Danube loess basin: Sedimentogenetic implications*. Quaternary International, **351**: 14-24.
[103] Pană I., Bonig H., Botez R. (1968). *Elemente noi de faună levantină din regiunea Buzău*. Petrol şi Gaze, **XIX**/1: 699-701.

6. The Mud Volcanoes

Brief history of the geological-paleontological knowledge. The first publication was made by Coquand (1867)[104], who described the Mud Volcanoes from Berca, followed by the publication of Cobălcescu (1883)[105]. The aforementioned brief information was later detailed by Teisseyre (1924)[106], Krejci-Graf (1935)[107] and Ciocârdel (1949)[108]. These authors linked the occurrence of the mud volcanoes to the existence of hydrocarbon accumulation of the Berca-Arbănaşi anticline. A first synthesis of the occurrence and significance of the mud volcanoes occurring on the Romanian territory belongs to Peahă (1965)[109].

Major contributions concerning the methane and other gases emanations of the Mud Volcanoes from Berca were published by Etiope *et al*. (2004)[110]; Baciu *et al*. (2007)[111]; Baciu *et al*. (2010)[112] and Frunzeti *et al*. (2012)[113].

Besides, the relationship between mud volcanoes occurring in the Berca-Arbănaşi area and the seismicity of this zone (linked to the Vrancea area) were pointed out by Baciu & Etiope (2005)[114]. Studies concerning the mud mineralogy and chemistry emitted by the volcanoes situated in Pâclele Mari and Pâclele Mici belong to Schniukov *et al*. (2009)[115] and Madeja & Mrowczyk (2010)[116]. These authors also proposed these sited to be integrated in a geotourism tour of the region.

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[104] Coquand H. (1867) *Sur le gîtes de pétrole de la Valachie et de la Moldavie et sur l'âge des terrains qui les contiennent*. Bull. Soc. Géol. Fr., 2-ème Série, **XXIV**: 505-570, Paris.
[105] Cobălcescu Gr. (1883). *Studii geologice şi paleontologice asupra unor terâmuri terţiare din unele părţi ale României.* Mem. Geol. ale Scolei Milit. din Iaşi, 161 pag., 16 pl., Bucureşti.
[106] Teisseyre W. (1924). *Le phénomène des volcans de boue dans les Carpathes et la loi de migration des hydrocarbures*. Kosmos, Bull. Soc. Pol. Nat., **49**: 295-298.
[107] Krejci-Graf K. (1935). *Die entstehung vulkanartiger Bauformen in Erdölgebieten*. Bohrtechniker Zeitunng, **6**.
[108] Ciocârdel R. (1949). *Regiunea petroliferă Berca-Beciu-Arbănaşi*. Com. Geol., St. tehn.-econ., **A1**, 32 p., Bucureşti.
[109] Peahă M. (1965) *Vulcanii noroioşi din România*. St. cerc. geol., geofiz., geogr., geografie, **XII**/2: 193-206, Bucureşti.
[110] Etiope G., Baciu C., Caracausi A., Italiano F., Cosma C. (2004). *Gas flux to the atmosphere from mud volcanoes in eastern Romania*. Terra Nova, **16**: 179-184.
[111] Baciu C., Caracausi A., Etiope G., Italiano F. (2007). *Mud volcanoes and methane seeps in Romania: main features and gas flux*. Annals of Geophysics, **50**/4: 501-511.
[112] Baciu C., Etiope G., Spulber L., Costin D., Pop C. (2010). *Romanian mud volcanoes – main features and flux to the atmosphere.* Geol. Balkanica, XIX Congr. Carpathian-Balkan Geol. Assoc., Abstract volume, p. 35-36, Thessaloniki, Greece.
[113] Frunzeti N., Baciu C., Etiope G., Pfanz H. (2012) *Geogenic emission of methane and carbon dioxiode at Beciu mud volcano (Berca-Arbanasi hydrocarbon bearing structure, Eastern Carpathians, Romania)*. Carpathian Journal of Earth and Environmental Sciences, **7**/3: 159-166.
[114] Baciu C., Etiope G. (2005). *Mud volcanoes and seismicity in Romania*. In: Martinelli G. & Panahi B. (eds.) Mud volcanoes, Geodynamics and Seismicity, NATO Sci. Ser. Earth Environ., **51**: 77-88.
[115] Schniukov E. F., Panin N. S., Dinu C., Kutniy V. A., Maslakov N. A. (2009) *Mud-volcanoes of Romania. Preliminary data on the mineralogy of Pâclele Mari and Pâclele Mici mud-volcanoes*. Geo-Eco-Marina, **15**: 131-137.
[116] Madeja G., Mrowczyk P. (2010) *Phenomenon of mud volcanoes in western Romania as a geoturism object*. Sci. Annals, School of Geology, Aristotle University of Thessaloniki. Proc. the XIX Carpatho-Balkan Congress, Special volume **100**: 491-502, Thessaloniki.

The Berca-Arbănaşi structure, which is linked to the appearances of the mud volcanoes from Berca, is an anticline fold (Paraschiv, 1975[117]), which extends on around 30 km from N to S. The anticline is axially faulted, causing an asymmetry to the whole structure (**Plate 42**). The anticline flanks are fragmented by transversal faults, largely sealed (Melinte-Dobrinescu *et al*., 2017). The mapping activity and dug wells, which reached the maximum depth of 3,331 m, revealed a succession of layers, from Pliocene (Romanian stage) down to the Middle Miocene (Sarmatian stage).

The accumulations of hydrocarbons are located in the Sarmatian and Meotian eastern Paratethyan stages. According to Paraschiv (1975), the nature and distribution of the fluids in this structure is: Arbănaşi eastern flank – oil; Beciu eastern flank – oil; Beciu western flank – oil; Pâclele eastern flank – oil, primary gas cap, and free gas. Hence, in the Berca-Arbănaşi structure, the eastern flank is productive in all the sectors, while the western flank contains hydrocarbons only at Pâclele and Beciu. Their exploitation began in 1894 and continues today.

Recently, Brustur *et al*. (2015)[118] brought new data regarding the location, morphology, dimensions and classifications of the mud volcanoes from Pâclele Mari and Pâclele Mici. They described at Pâclele Mari and Pâclele Mici mud volcanoes 38 cones showing punctiform ejections, 37 with multiple ejections, 6 with diffuse ejections, 1 bilateral, 13 punctiform ones, 2 with lateral ejection and 4 cones that were inactive (data collected in 2010).

6.1. Beciu Mud Volcano (*Vulcanul noroios de la Beciu*)

The Beciu Mud volcano (Coordinates: Latitude 45°23'05.36" N; Longitude 26°42'58.88" E), located in the village Mărgăriți of the Beceni commune, is situated at the altitude of 280 m on a surface of around 20 x 40 m, at the northern edge of the Berca-Arbănaşi anticline. Because the ejected mud is more fluid as the one from Pâclele Mari and Pâclele Mici volcanoes, the cones are not so high, but this volcano is also very active.

In the area occupied by the Beciu Mud Volcanoes (**Plate 43a**) there are small mud cones, up to 50-60 cm (**Plate 43b**), flows (**Plate 43c**, **44a**) made by grey-blackish mud ejected throughout small cones (**Plate 44b**). Polygonal drying cracks may be seen also on the small plateau where the cones of Beciu Mud Volcano are situated (**Plate 44c**). In the past, two significant landslides occurred in the area, concomitantly with more intense mud emissions; some of the aforementioned events are linked to the 4th of March 1977 strong earthquake (Sencu, 1985[119]).

[117] Paraschiv D (1975). *Geologia zăcămintelor de hidrocarburi din România.* Stud. Tehn. Econ. Seria A, 10, 363 p.
[118] Brustur T., Stănescu I., Macaleţ R., Melinte-Dobrinescu M.C. (2015) *The mud volcanoes from Berca: a significant geological patrimony site of the Buzau Land Geopark (Romania)*. Geo-Eco-Marina, **21**: 1-23.

earthquake (Sencu, 1985[119]).

6.2. La Fierbători Mud Volcano (*Vulcanul noroios de La Fierbători*)

This mud volcano is located N of Berca locality, from which the route 203L goes towards E, up to the Pleșești village and then to the Pâclele village (Coordinates: Latitude 45°17'47.7" N; Longitude 26°41'39.3" E), N of the Berca locality, at 290 m altitude. The characteristic of this site is the significant presence of crude oil occurring on the plateau together with gas emissions (mostly methane), the later ones being frequent also in the other areas of mud volcanoes situated on the Berca-Arbănași structure. Cobălcescu (1883) indicates that the activity in this area started in the spring of 1881, when suddenly occurred a salty and cold mud.

Rather than cons, on the plateau there are calderas 1-1.5 m (**Plate 45 a,b**) in diameter, filled with oil and mud. From the plateau of this mud volcano there is a spectacular view on the Buzău Valley; this is also a characteristic of the La Fierbători Mud Volcano.

6.3. Pâclele Mici Mud Volcano (*Vulcanul noroios Pâclele Mici*)

Pâclele Mici Mud Volcano is situated in the northern part of Berca depression, at 341 m (Coordinates: Latitude 45°20'22" N; Longitude 26°42'30.2" E), on the territory of Scorțoasa commune, close to the county road DJ108 that connects Policiori village with Pâclele village. It is a Natural Reserve Category IV IUCN – geological, faunal and floral, occupying 10.2 ha on a circular plateau (**Plate 46**). The crater diameter varies between 10 and 200 cm, while the cone height is up to 1 m, but commonly between 40-50 cm (**Plate 47a, b**). Frequently, mud cracks, mostly pentagonal, formed when the mud ejected from the cones dries and contracts by losing the fluids, may be seen on the whole plateau (**Plate 47c**). At its edges, on the plateau torrential valleys and meandering shafts arranged radially may be seen (**Plate 48a**). Multiple ejections or punctiform ones are present (**Plate 48b, c**).

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[120]). The protected faunas of this site contain 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 being known by local people as “The Big Dragon”. Methane emissions of the Pâclele Mici Mud Volcano were estimated to 383 tones/year (Etiope *et al*., 2004).

[119] Sencu V. (1985). *Vulcanii noroioşi de la Berca*. Ed. Sport-Turism Bucureşti. 21 pp.
[120] Evelpidou N., de Figueiredo T., Mauro F., Tecim V., Vassilopoulos A. (2010). *Natural heritage from east to west: case studies from 6 EU countries*. Springer Science & Business Media, Berlin, 384 pp.

6.4. Pâclele Mari Mud Volcano (*Vulcanul noroios Pâclele Mari*)

This is a geological, faunistic and floristic nature reserve (with a surface of 15.2 ha). It is a protected area of national interest, Category IV IUCN (geologic, botanic and faunistic). The nature reserve (Coordinates: Latitude 45°21'31.1" N; Longitude 26°42'43.8" E) is located in the central part of the Buzău county (at the altitude of 322 m), on the administrative territory of Scorțoasa district, near the county road DJ108 which links the Policiori and Pâclele villages. Pâclele Mici and Pâclele Mari are protected areas since 1924. In the year 2008, these two mud volcanoes received the status of NATURA 2000 site, i.e., Nature Reserve ROSCI0272, occupying 93.8 ha.

The occurrence of the cones that are up to 200 cm height is linked to the ejection of the mud, i.e., gas, mostly methane, coming from more than 3,000 meters depth, which passes through a clay soil in combination with the groundwater. The gases are pushing to the surface water mixed with clay. The mud formed by them reaches the surface and dried in the contact with the air, forming cone-like structures similar with volcanoes. Methane emissions of the Pâclele Mari Mud Volcano were estimated to 730 tones/year (Etiope *et al*., 2004).

The soil contains sulfur and salt, improper for the vegetation. However, on the Pâclele Mari Mud Volcano plateau are developing some plant species adapted to this type of soil, i.e., *Nitraria schoberi* and *Obione verrucifera*, similar to other mud volcanoes from the area. A circular arid plateau may be seen, along with active and extinct cones, as well as calderas (**Plate 49**).

The four mud volcanoes occurring on the Berca-Arbănași structure (Pâclele Mici, Pâclele Mari, Beciu and La Fierbători) are vulnerable sites, being impacted both by natural phenomena (pluvial denudation, surface erosion, rain-wash and gullying) and by the anthropic activities.

PLATES

PLATE 0 - Romanian and foreign geologists with notable contributions on the geology and palaeontology of the Tertiary deposits from the Buzău Land Geopark and surrounding areas.
1.Grigore Cobălcescu (1831-1892); 2. Sabba Ștefănescu (1857-1931); 3. Wawrzyniec Teisseyre (1860-1939); 4. Otto Protescu (1882-1954); 5. Karl Krejci-Graff (1898-1986); 6. Miltiade Gh. Filipescu (1901-1993); 7. Wilhelm Wenz (1886-1945); 8. Nicolae Grigoraș (1913-1969); 9. Radu Ciocârdel (1915-2010); 10. Neculai Macarovici (1902-1979); 11. Ionel Motaș (1932-1982); 12. Ioana Pană (1928-2011); 13. Ioan Papaianopol (1940-1998); 14. Ion Andreescu; 15. Nicolae Țicleanu (1943-2009); 16. Mihai Ștefănescu (1937-2008); 17. Gheorghe Popescu; 18. Paulian Dumitrică; 19. Dan Jipa; 20. Marius Stoica.

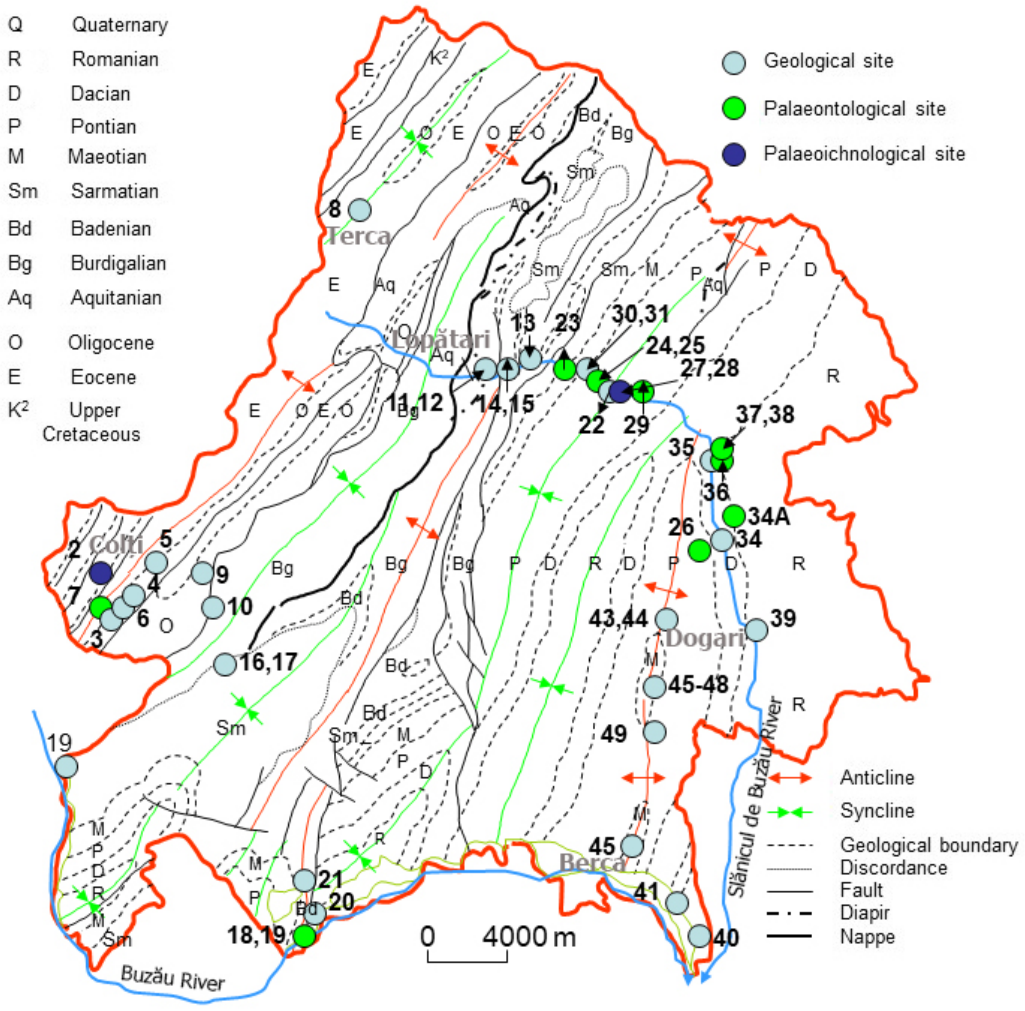


PLATE 1 – Geological map of the Buzău Land Geopark (compiled after Motaș *et al*., 1967; Dumitrescu *et al*., 1968; Ștefănescu e*t al*., 1993; Melinte-Dobrinescu et *al*., 2016) comprising the location of the geological and paleontological sites.

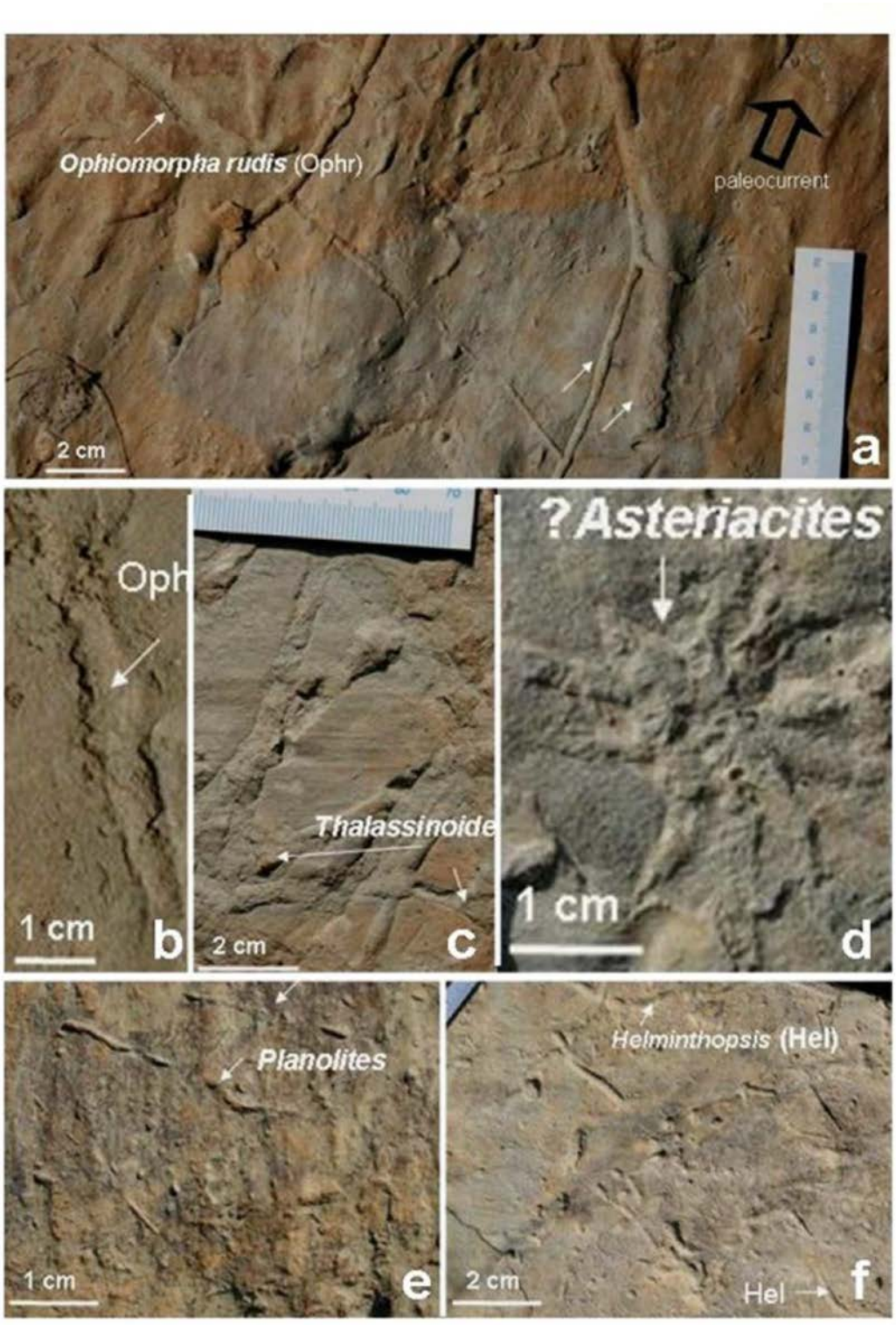


PLATE 2 – Eocene ichnofaunas of the Colţi Facies (Photos Titus Brustur). Oph – *Ophiomorpha*.

PLATE 3 – Kliwa Formation composed of folded and faulted shally turbidites outcropping in the Colţi area (Photos Adrian Popa).

PLATE 4 – a: Intraformational folds in the Lower Kliwa Formation at Plaiul Nucului (Photo Adrian Popa); b: The „Wall of the Giants" from Bozioru; vertical beds of massive siliceous fissured Oligocene sandstones, Kliwa type (Photo Rodica Macaleţ).

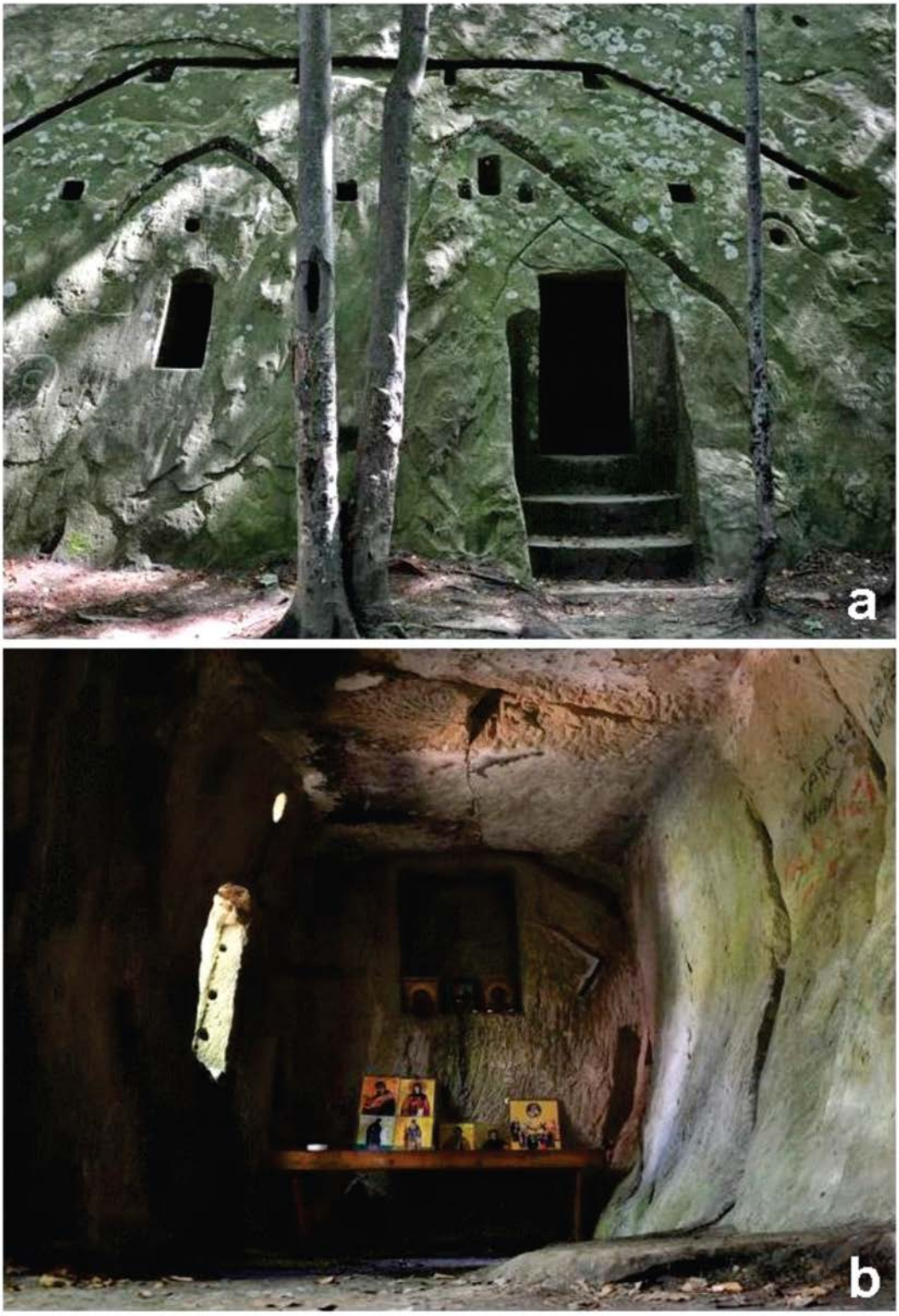


PLATE 5 – Cave cells from Bozioru-Aluniş area carved in Kliwa Formation sandstones (Photo Titus Brustur and Adrian Gherghe).

PLATE 6 – Above: The entrance at the Amber Museum from the Colţi village (Photo Adrian Popa); Below: Red-blackish amber (Photo Titus Brustur).

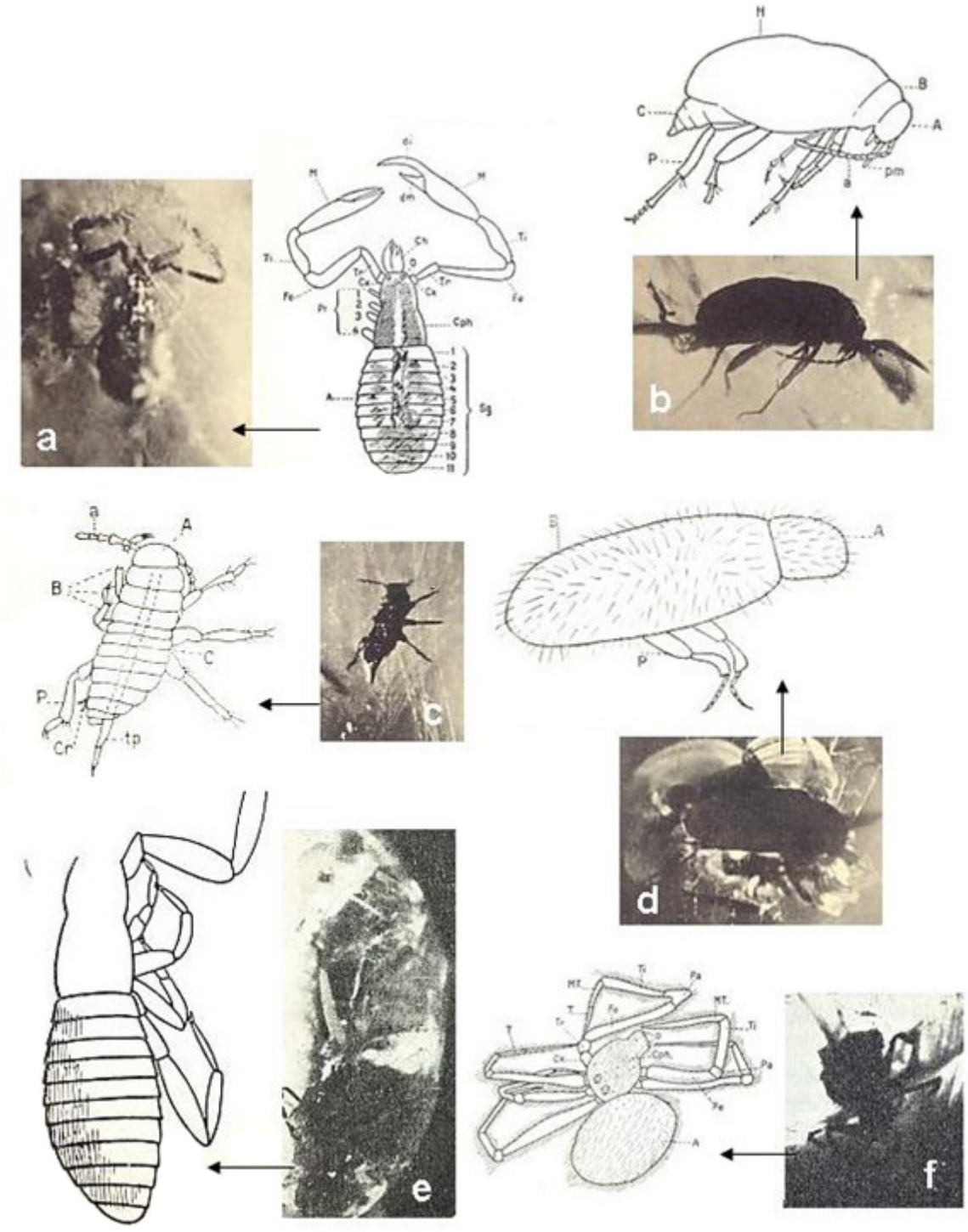


PLATE 7 – From Protescu (1937) – Geological and paleobiological study of the Romanian Amber (Organic inclusions of the Buzău Amber) – in French. a: *Cheiridium* aff. *ferum;* b: *Scyrtes* aff. *hemisphaericus;* c: *Lachnus aff. drepides;* d: *Dryocoetes* aff. *autographus*; e: *Theridium* aff. *Hirtum*; f: *Theridium* sp.

PLATE 8 – Everlasting Fire (Focul Viu) from Terca (Photos Andrei Briceag).

PLATE 9 – a: Lower Kliwa Formation in the Fişici village (Photo Mihaela Melinte-Dobrinescu); A, B, C – mineral springs of Fişici (Photos Adrian Gherghe)

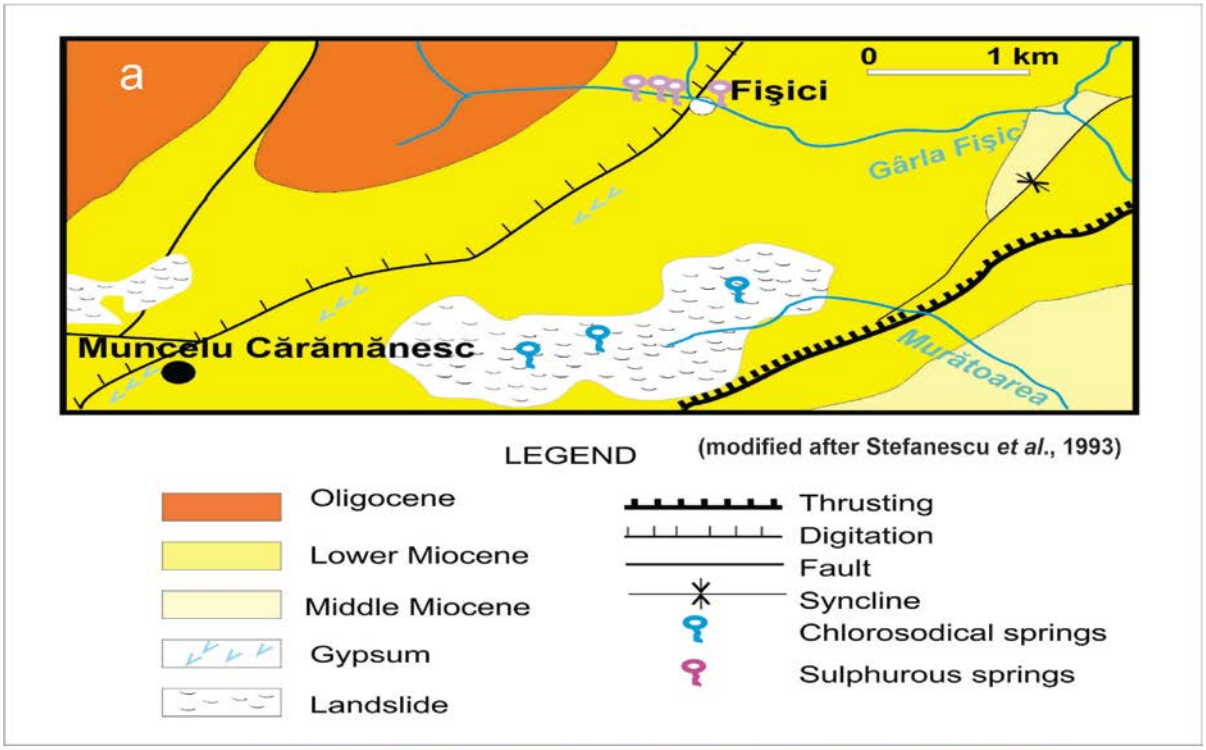


PLATE 10 – a: Location of the Muncelu Cărămănesc Gypsum (modified and redrawn after sheet Nehoiu, 1: 50,000 – Ștefănescu *et al*., 1993; b: Vertical beds with gypsum and clays (Photo Mihaela Melinte-Dobrinescu).

PLATE 11 – Salt Mountain from Mânzăleşti, included in the Meledic Plateau Natural Reserve (Photos Adrian Popa).

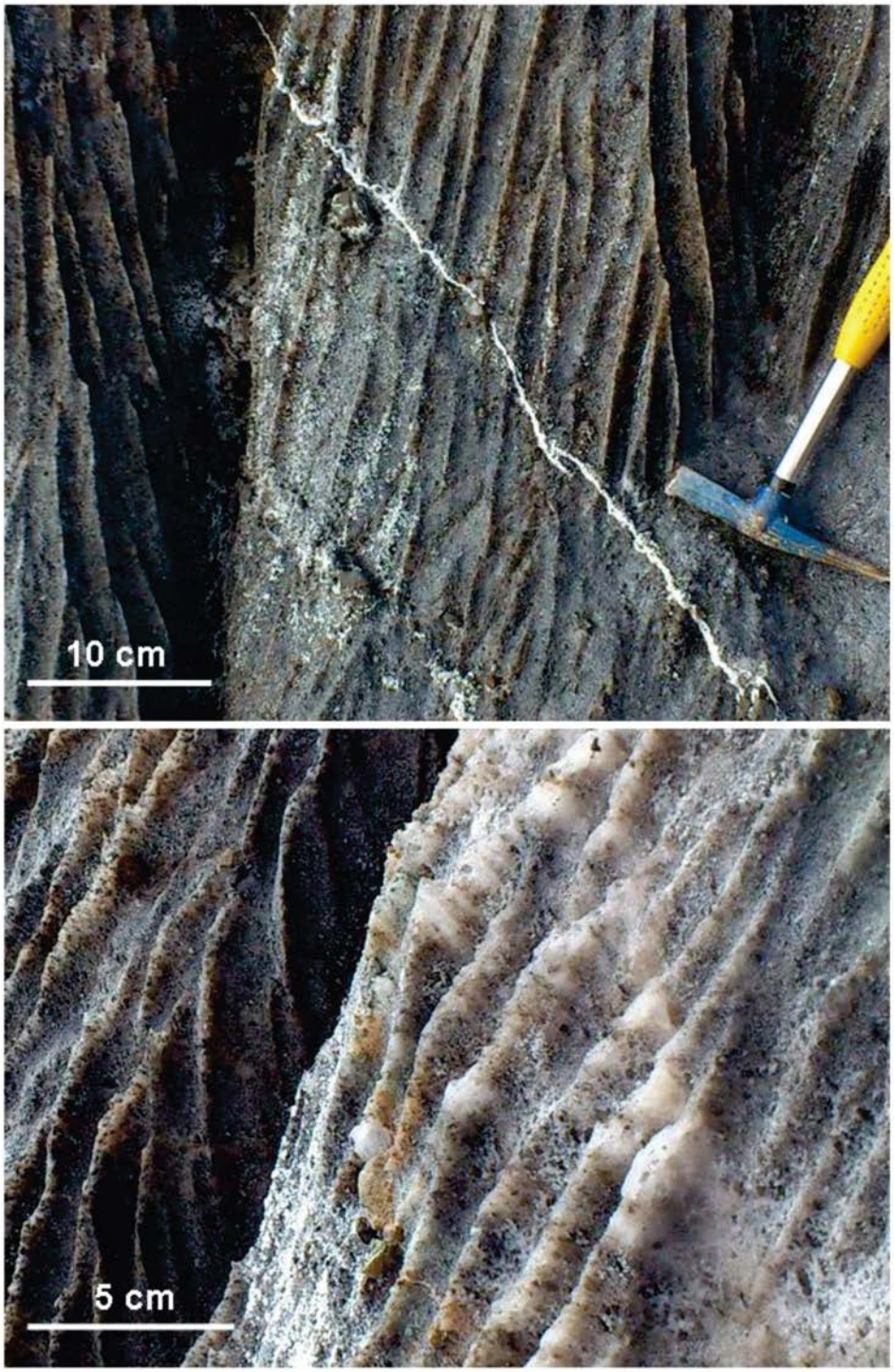


PLATE 12 – Microstructures in the Salt Mountain from Mânzăleşti (Photos Gabriel Ion).

PLATE 13 – The White Stone (=Piatra Albă) „La Grunj” (Photos Gabriel Ion).

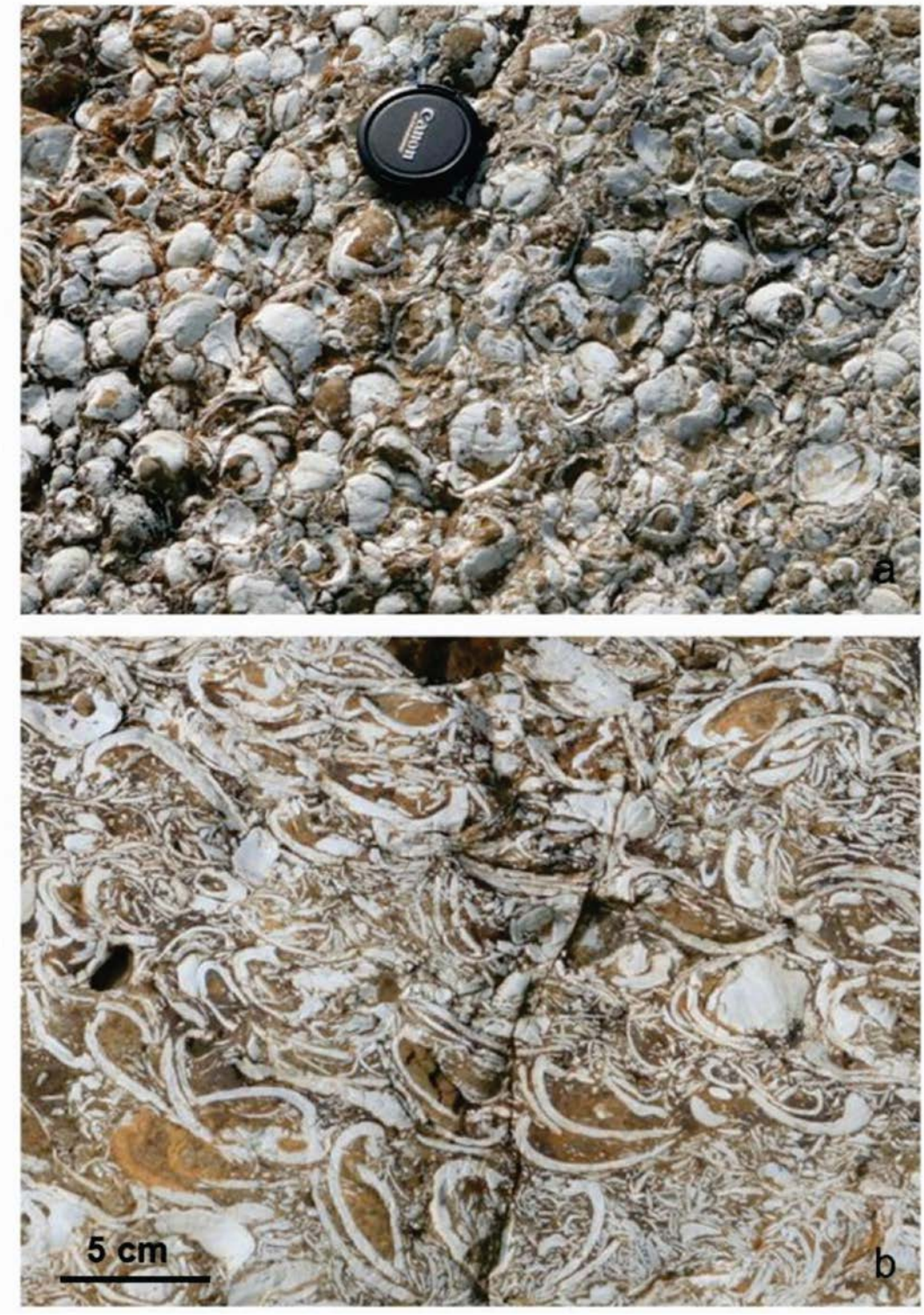


PLATE 14 – Lower Sarmatian (Volhinian) coquinas close to the Pănătău locality (Photos Titus Brustur).

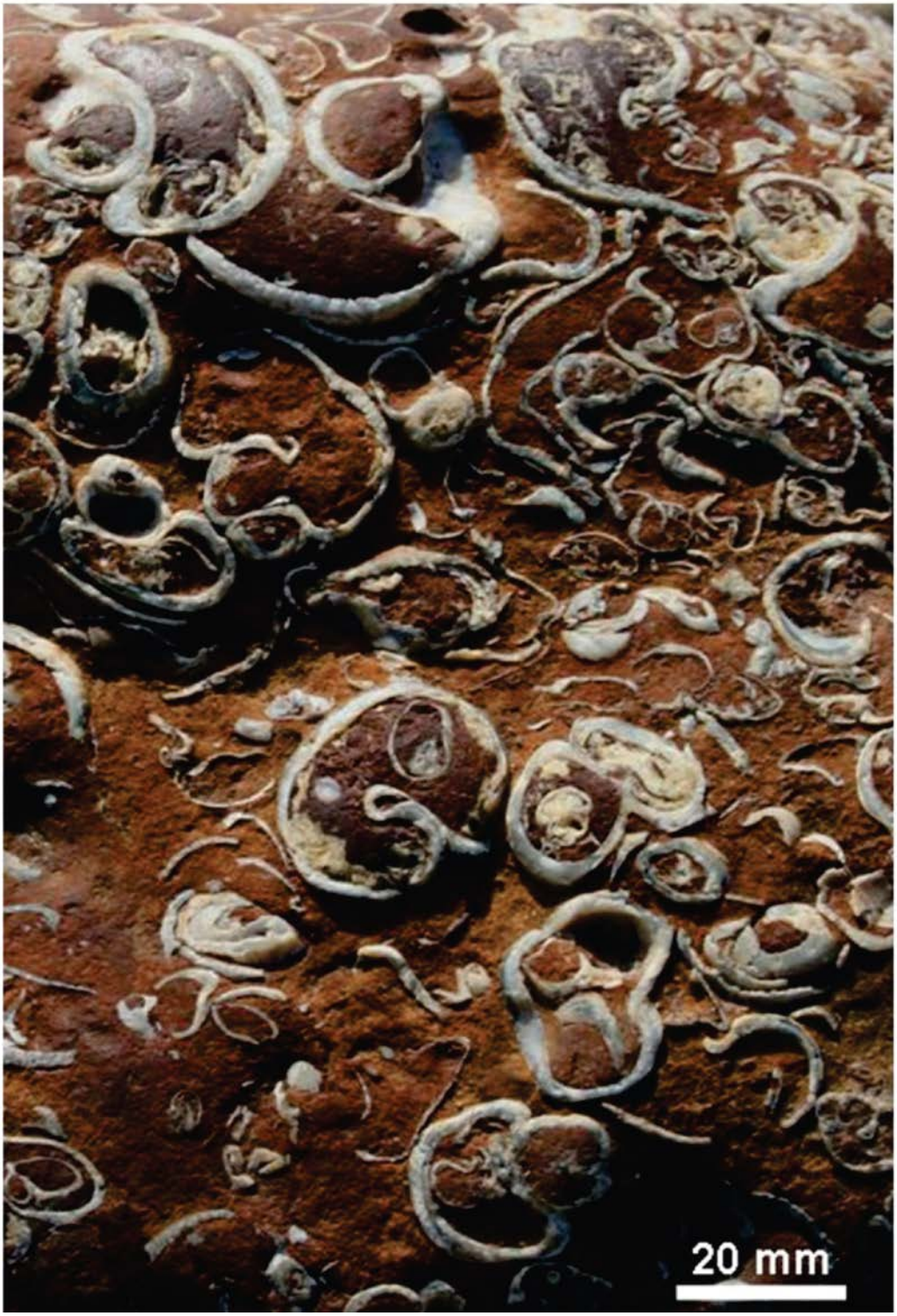


PLATE 15 – Upper Sarmatian (Khersonian) coquinas and moulds occurring on the Buzău and Slănicul de Buzău valleys (Photo Titus Brustur).

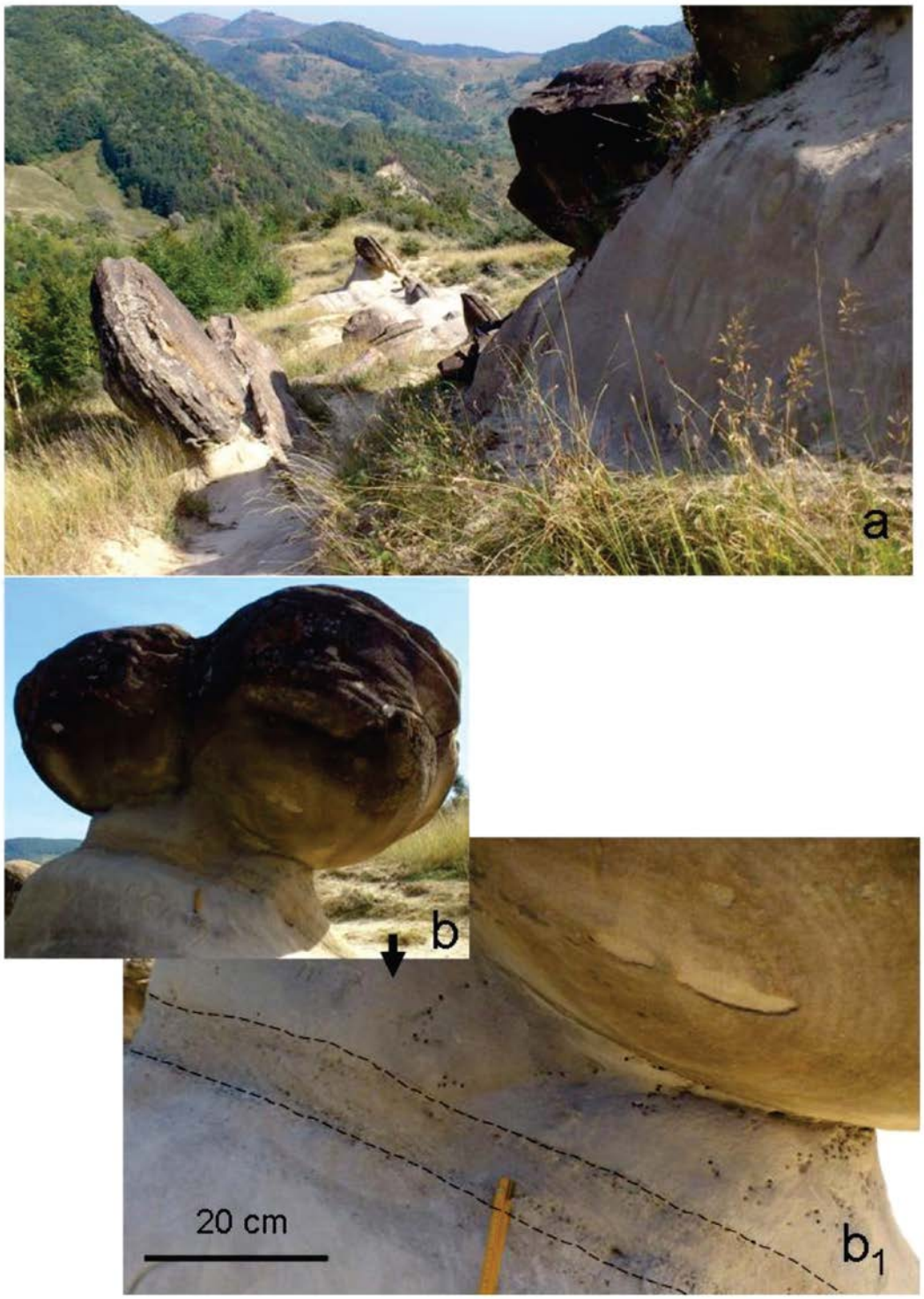
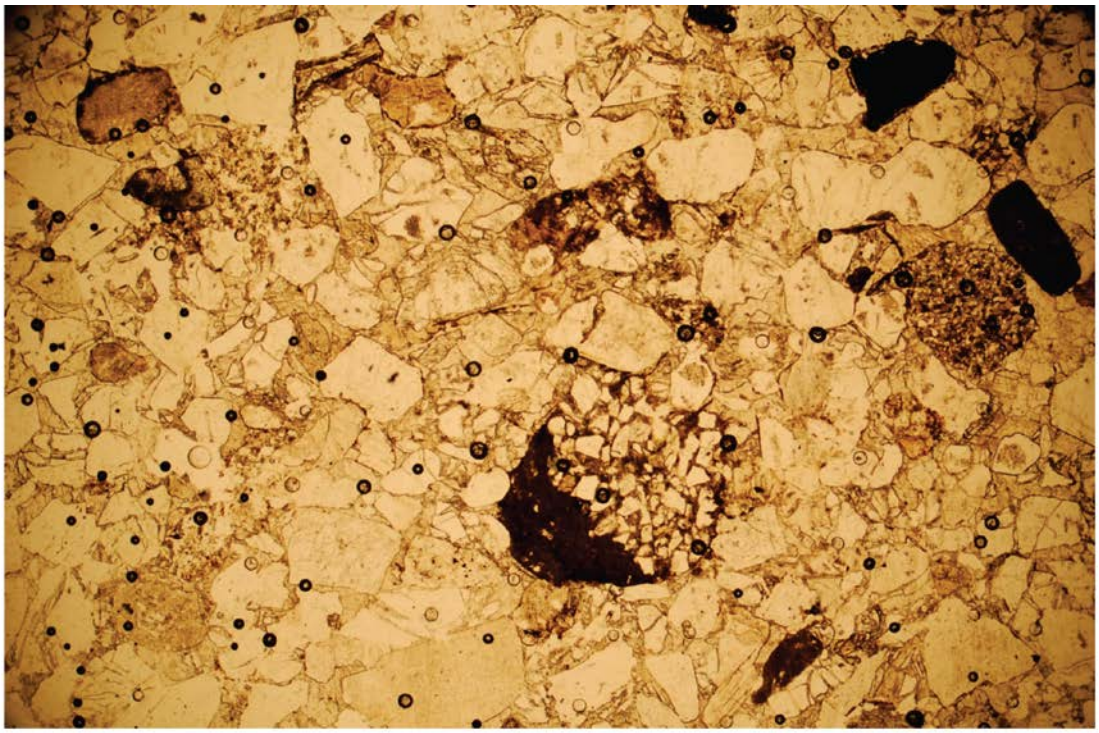


PLATE 16 – Concretions known as Babele (the Old Ladies) exposed at the Ulmet site. a – embedded concretions in the sandy substratum, disposed on parallel alignments, which indicate on the relief the NW boundary of the syncline Bozioru-Odăile; b – spherical concretions almost detached from the sandy substratum; b_1 – microsequences with crossed lamination (Photos Gabriel Ion).



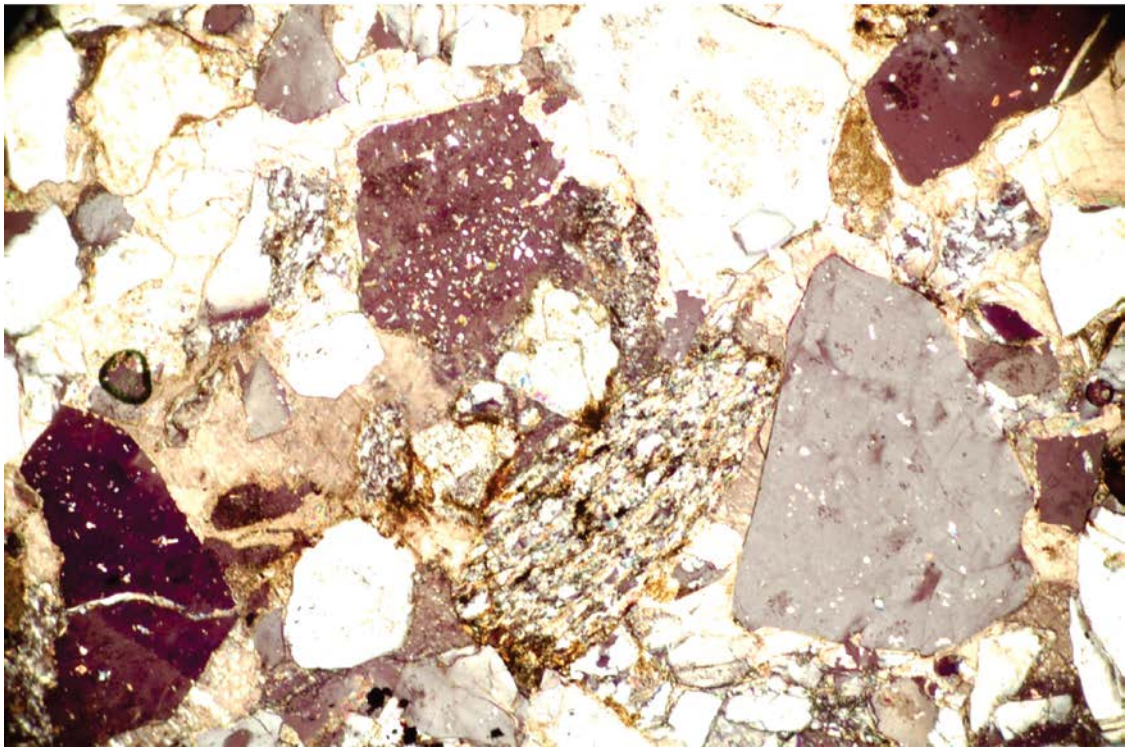


PLATE 17 – Mineralogical aspects of Babele (the Old Ladies). Microphotographs at Light Microscope (LM), description and interpretation by Relu-Dumitru Roban (University of Bucharest, Faculty of Geology and Geophysics). Above: 4X=5.8 mm, NII (parallel nicols). Quartz, sedimentary (mainly limestone) and metamorphic fragments; subangular to subrounded clasts. Below: 10X=2.2 mm, N+ (crossed nicols). Detail: monocrystalline and polycrystalline quartz; up to the right: muscovite and glauconite.

PLATE 18 – Above: m-thick conglomerate blocks with elements of green schists and limestone at Bădila in the Buzău River riverbed; Below: salt breccia at Bădila on the Buzău River left bank (Photos Adrian Popa).

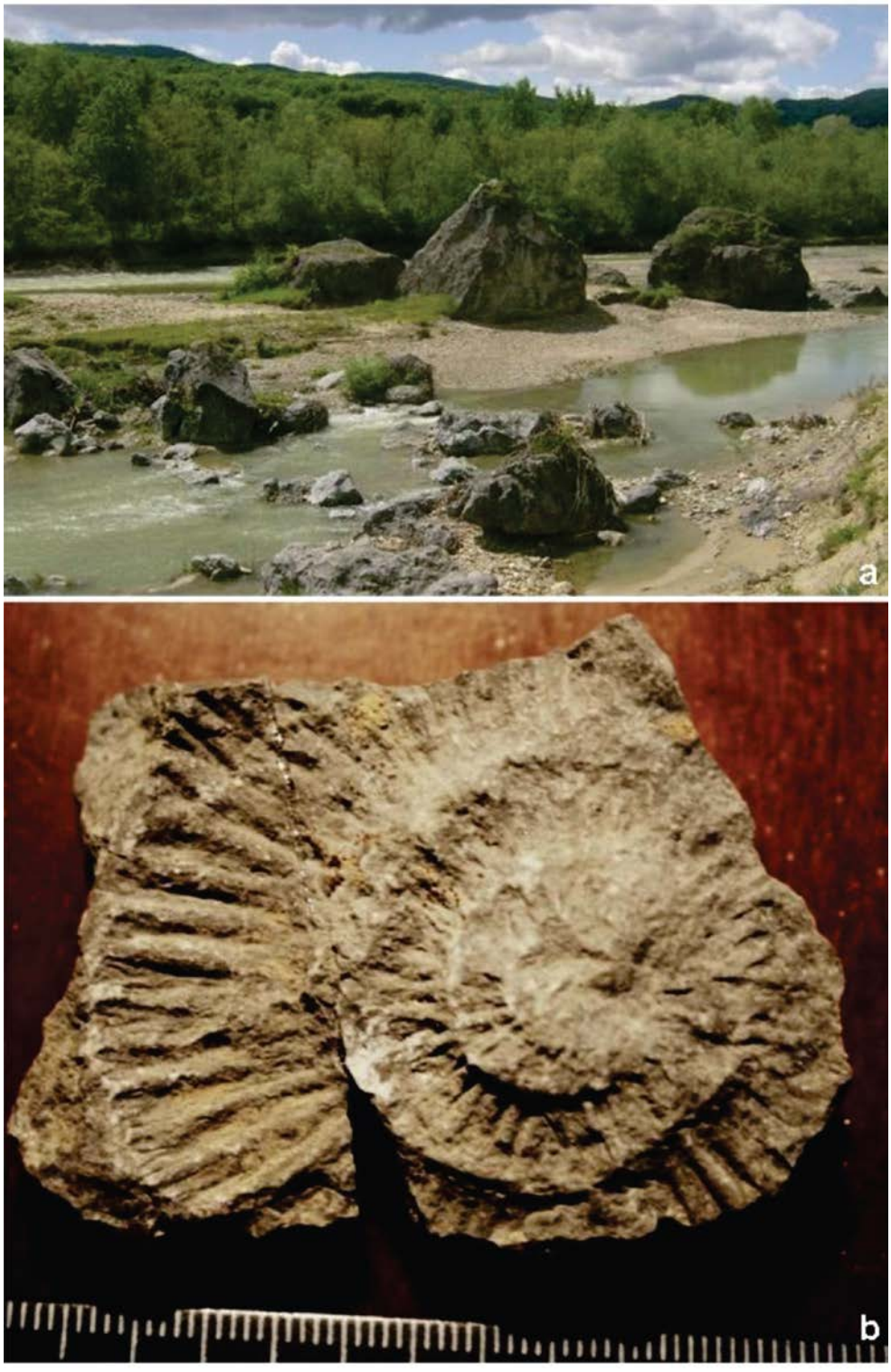


PLATE 19 – a: Jurassic blocks at Bădila in the Buzău River bed (Photo Adrian Popa); b: The genus *Perisphinctes* ammonite found in the Bădila Jurassic blocks (Photo Titus Brustur).

PLATE 20 – The Buzău's salt (Sarea lui Buzău) (Photos Adrian Gherghe).

PLATE 21 – Mud volcano from Bădila (Photos Adrian Gherghe).

PLATE 22 – Erosion witnesses situated at the Sârbeşti locality. Above: The Whale; Below: The lioness and the buffalo (Photos Titus Brustur).

PLATE 23 – Meotian faunas occurring in the Slănicul de Buzău Valley (Photos Rodica Macaleţ and Titus Brustur).

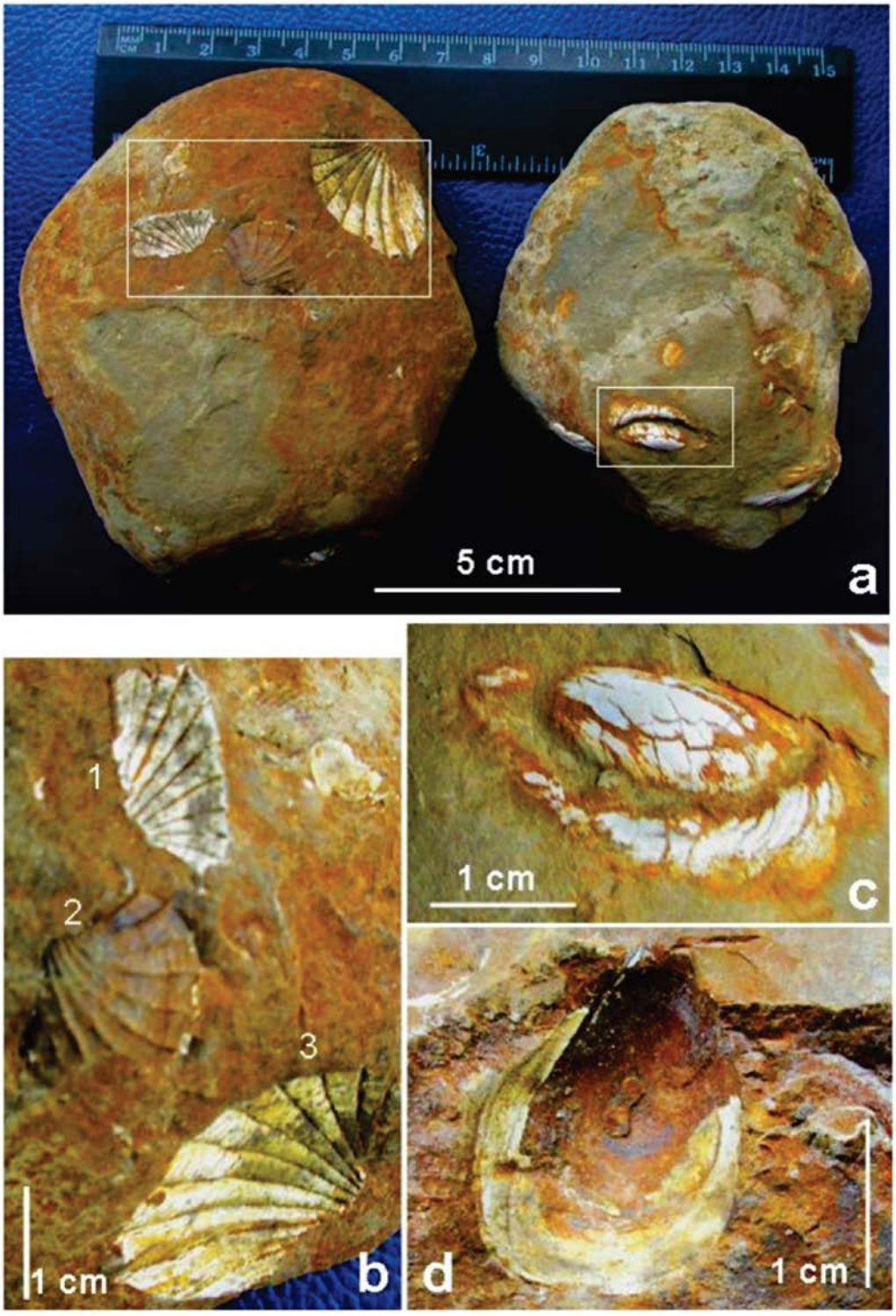


PLATE 24 – Lower Pontian (Odessian substage) fossil macrofaunas exposed at Sârbești, in the Slănicului de Buzău Valley: limestone concretions (24a), *Paradacna abichi* R. HÖRNES (24b1, 24b2), *Paradacna radiata* STEFANOVIČ (24b3), *Congeria* (*Rhombocongeria*) cf. *rumana* SABBA (24c) and *Dreissena simplex* BARBOT (24d). (Photos Titus Brustur).

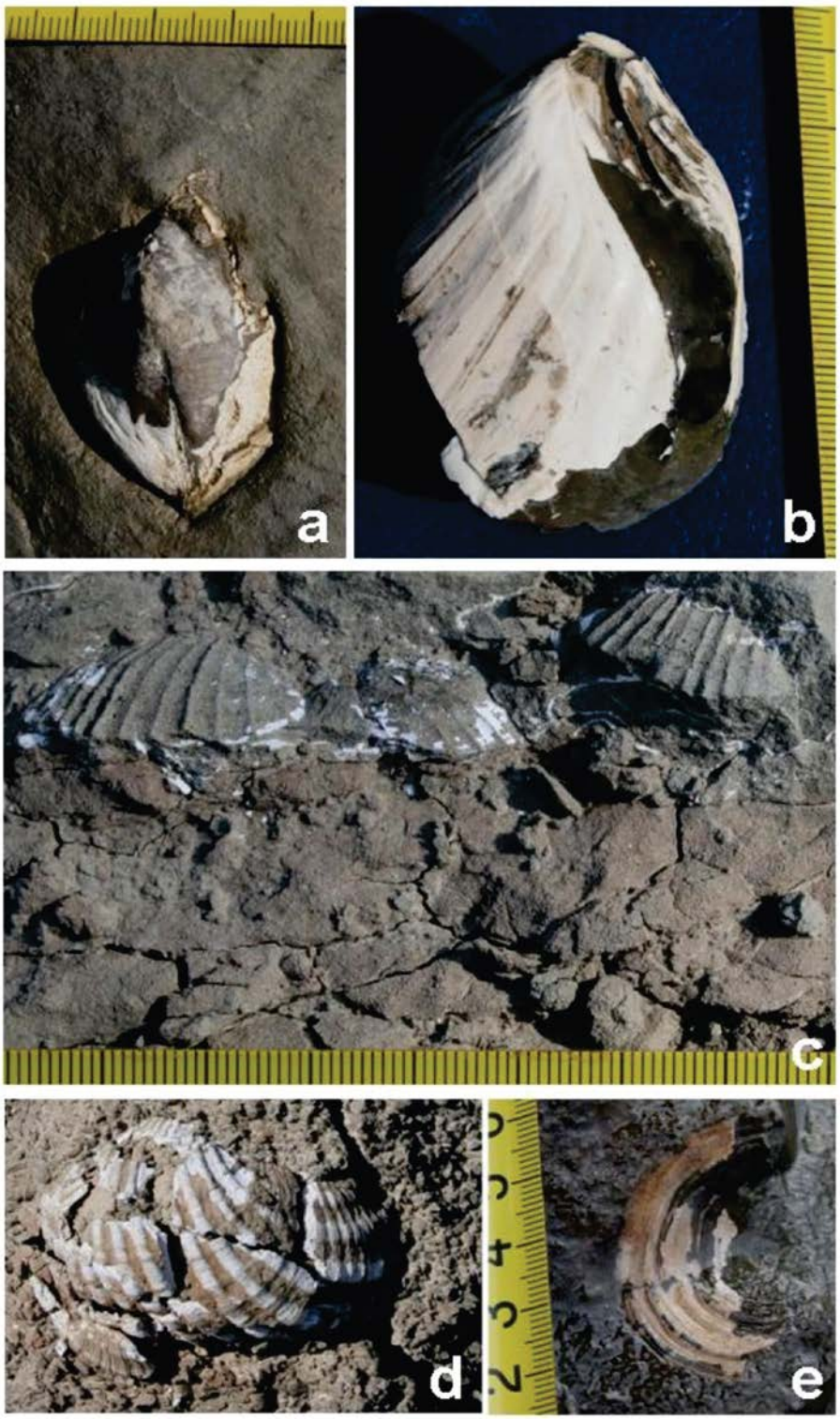


PLATE 25 – Middle Pontian (Portaferrian substage) fossil macrofaunas exposed at Sârbești, in the Slănicului de Buzău Valley: *Congeria* (*Rhombocongeria) rhomboidea* R. HÖRNES (25a, b), *Paradacna omivaga* PAPAIANOPOL (25c), *Luxuridacna magna* PAPAIANOPOL (25d), *Valenciennius* sp. (25e). (Photos Titus Brustur).

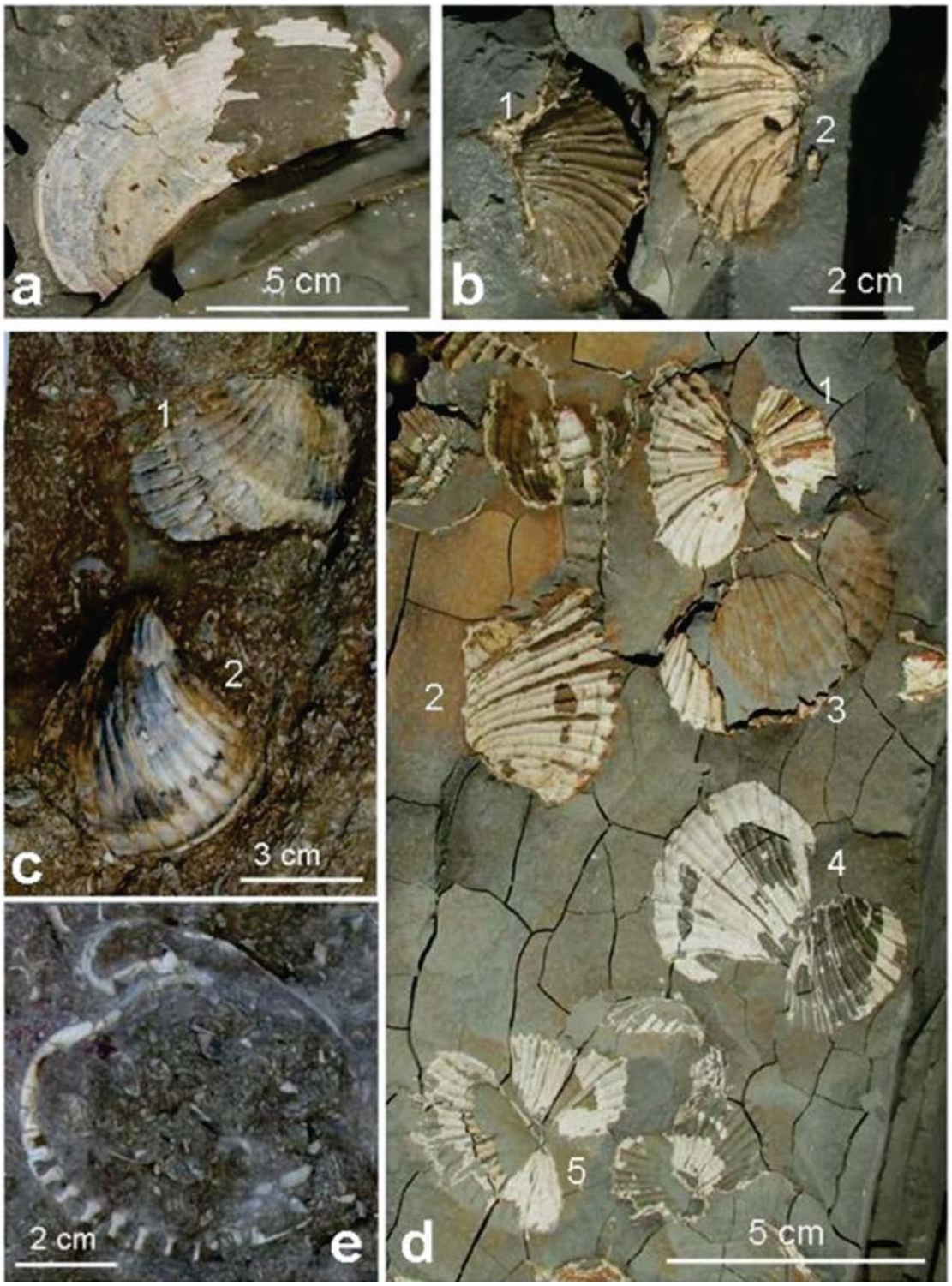


PLATE 26 – Upper Pontian (Bosphorian substage) fossil macrofaunas exposed in the Dogari – Sârbești area, in the Slănicului de Buzău Valley: *Valenciennius* sp. (26a), *Pseudocatillus simplex* (FUCHS) (26b1), *Caladacna steindachneri* (BRUSINA) (26b2; 26d2,3,5), *Stylodacna heberti* (COBALCESCU) (26c2, 26e), *Pseudoprosodacna littoralis* (EICHWALD) (26c1), and *Pontalmyra* (*Pontalmyra*) *sabbae* PAPAIANOPOL (26d4). (Photos Titus Brustur).

PLATE 27 – a: Middle Pontian feeding traces associated with undertracks (Photo Dan Jipa); b: reconstruction of the terrestrial faunas (Titus Brustur).

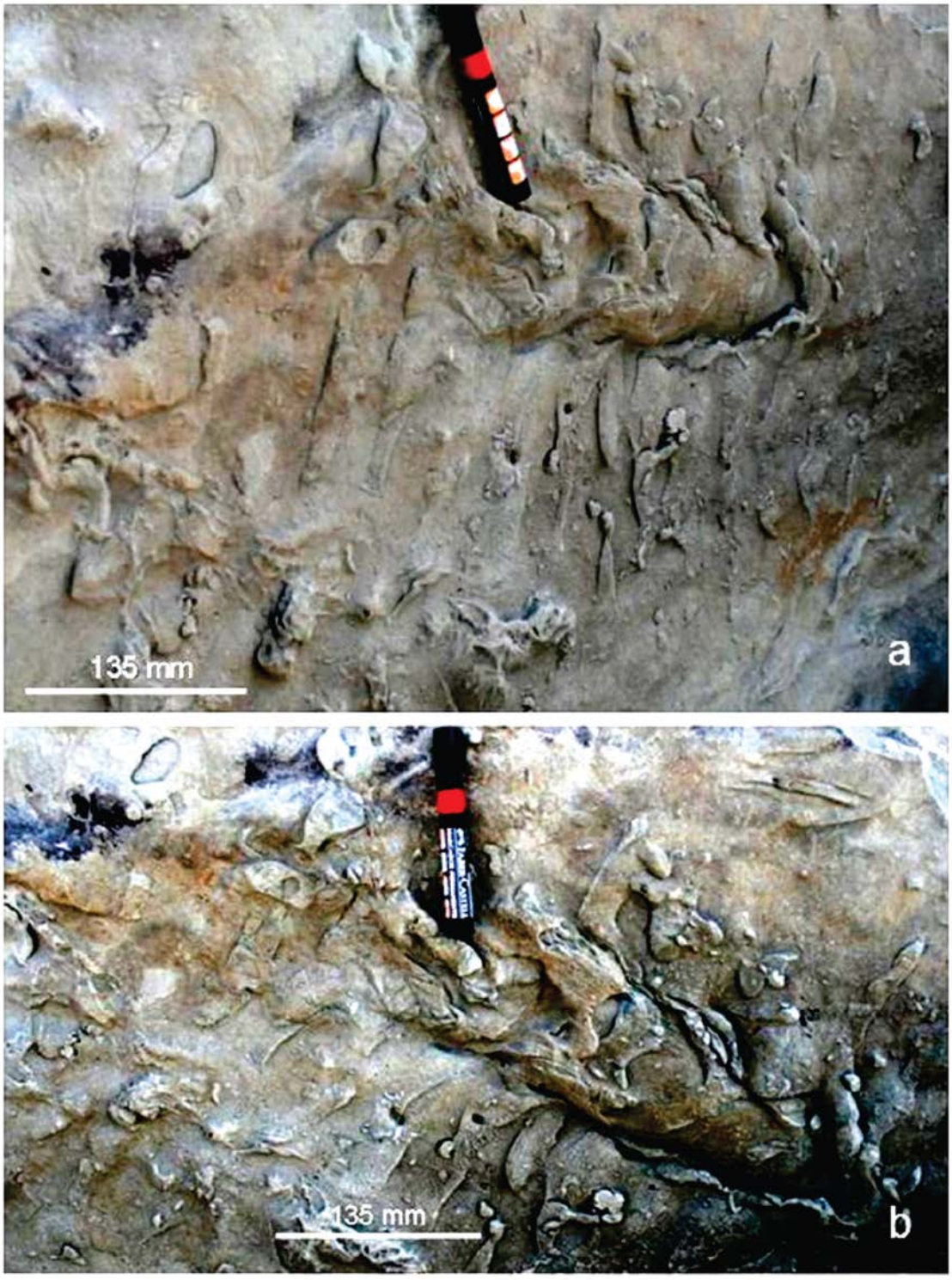


PLATE 28 – Hurricane prod-cast observed at the Sârbeşti locality (Photos Titus Brustur).

PLATE 29 – Rhizolithes identified at Sârbești (Photo a: Camelia Vărzaru; Photos b and c: Dan Jipa and Titus Brustur).

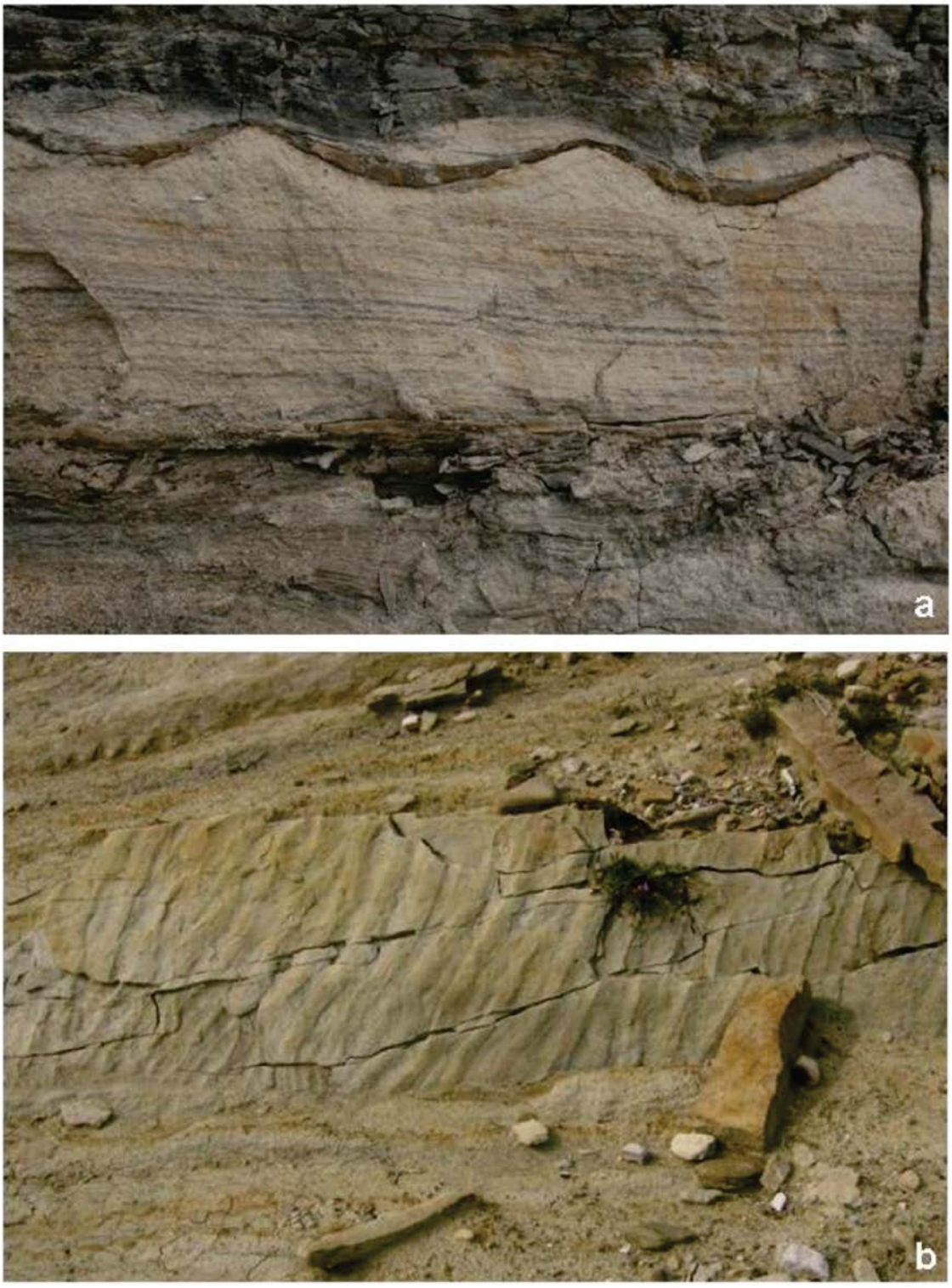
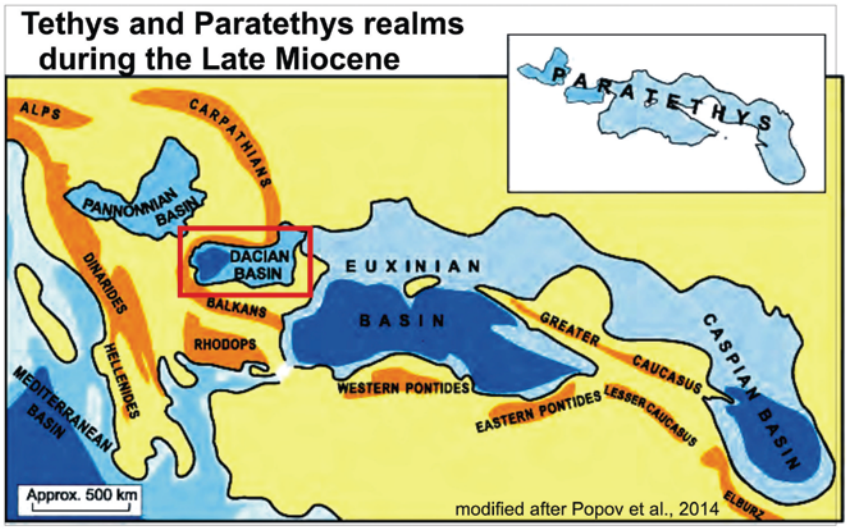


PLATE 30 – a: Traces of wave symmetrical oscillations; b: Current asymmetrical traces on the western flank of the Berca-Arbănaşi anticline (Photo a: Dan Jipa; Photo b: Titus Brustur).

PLATE 31 – a: Erosional contacts at the base of the fluvial pseudochannels; b: Synsedimentary structures c: Trace fossils of *Ophiomorpha* type (Photos Titus Brustur).



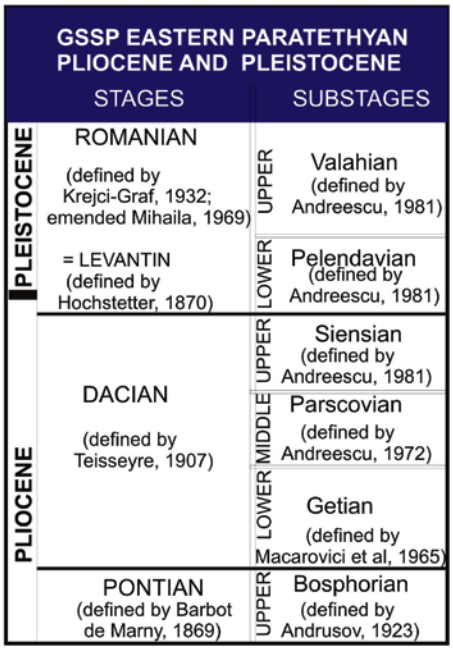


PLATE 32 – Above: Paleogeography of SE Europe and SW Asia during the Miocene times (modified after Popov *et al*., 2004) and location of the studied area; Below: Eastern Paratethyan regional stages and substages (after Andreescu, 2008 – *Magnetostratigrafia depozitelor sarmato-pliocene din estul Bazinului Dacic*. In: Avram C. & Melinte M.-C. (coord.) Paleoambianțe și paleodiversitate în contextulschimbărilor climatice, p. 5-116, Edit. Eikon, Cluj-Napoca) established for the Pliocene and Pleistocene interval

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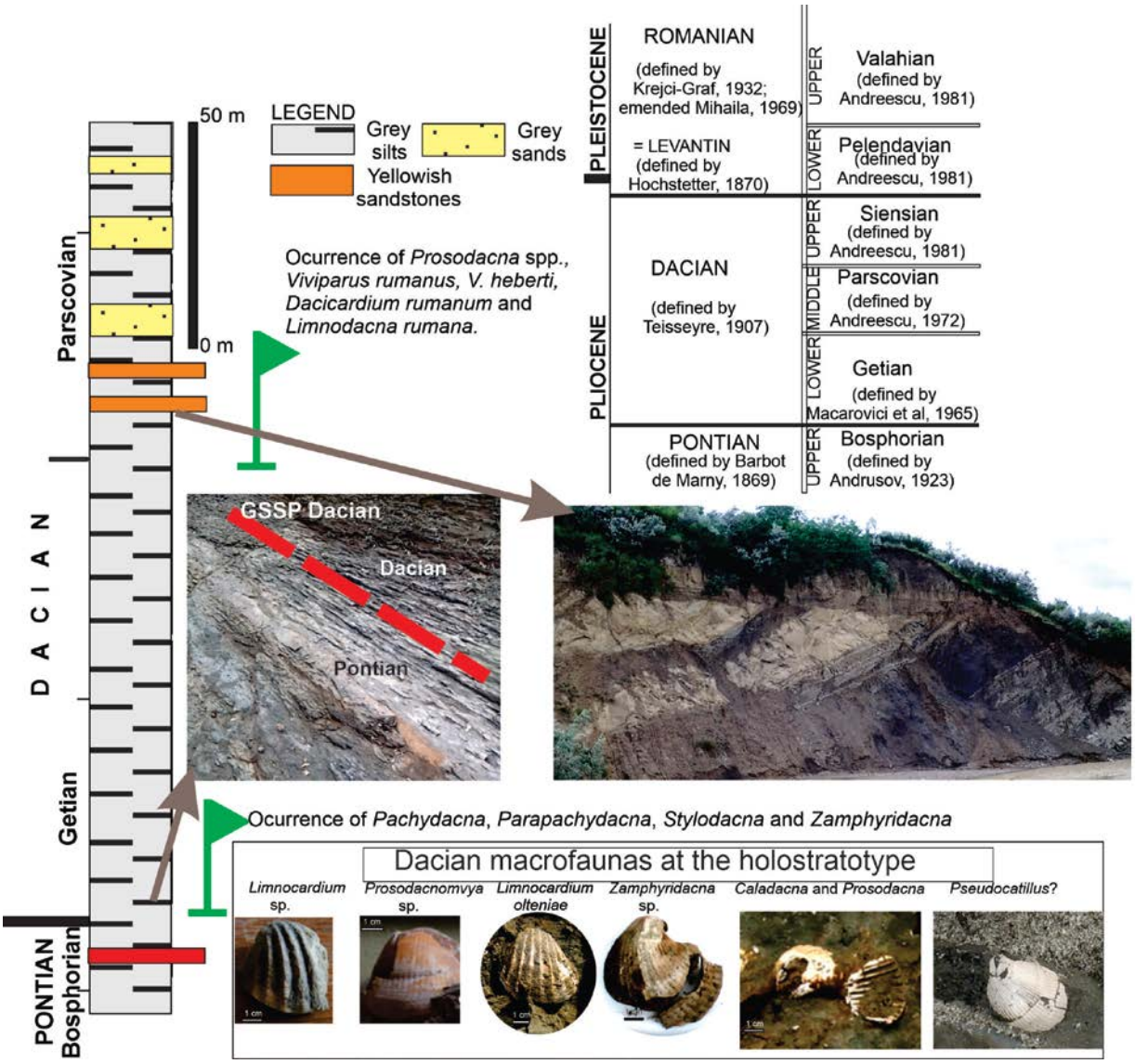


PLATE 33 – Lithology and biostratigraphy of the Upper Pontian stage (Bosphorian substage)-Middle Dacian stage (Parscovian substage) depositional interval cropping out in the Slănicul de Buzău Valley at Gura Dimieni (after Andreescu, 2008 – *Magnetostratigrafia depozitelor sarmato-pliocene din estul Bazinului Dacic*. In: Avram C. & Melinte M.-C. (coord.) Paleoambianțe și paleodiversitate în contextulschimbărilor climatice, p. 5-116, Edit. Eikon, Cluj-Napoca)

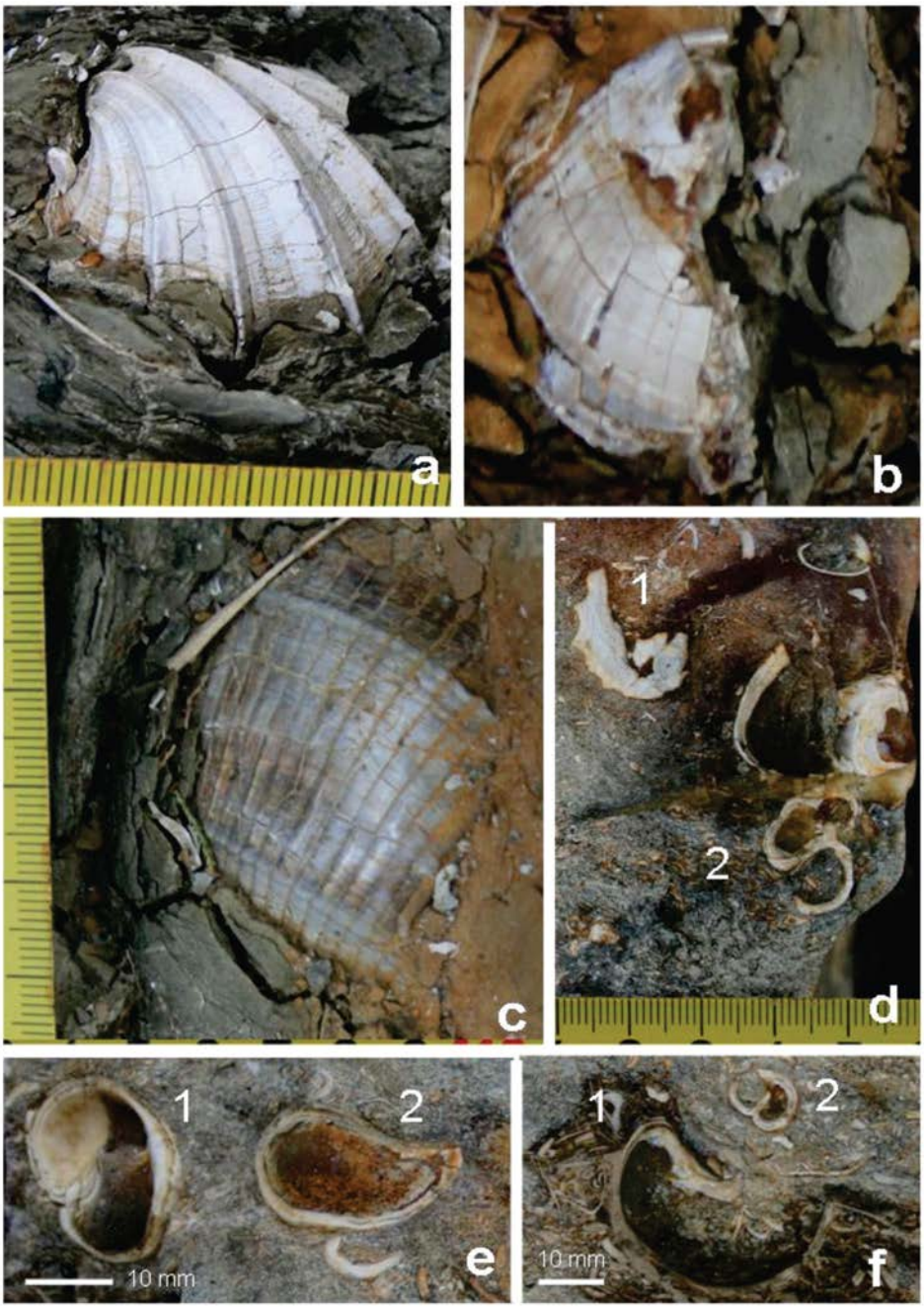
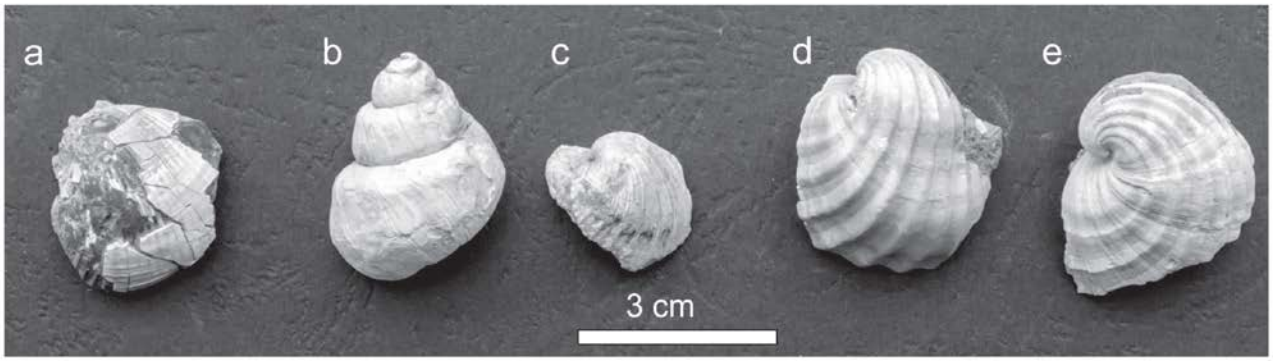


PLATE 34 – Late Pontian-Dacian macrofaunas at Gura Dimieni. *Prosodacna* (*Psilodon*) aff. *stefanescui* (a); *Dacicardium dacicus* (b, c); Heavily cemented calcareous sandstone shows internal sections of limnocardids (d1), tangential sections of *Viviparus* sp. (d2; f1, f2), *Theodoxus* sp. (e1), and internal molds of *Dreissena* sp. (e2). (Photos Titus Brustur).

A



B

PLATE 35 – A: Late Dacian macrofaunas in the Muchia Plopului Hill: a. *Prosodacnomya* aff. *sturi*; b – *Viviparus murgescui*; c. *Zamphiridacna* sp.; d, e. *Prosodacna* (*Psilodon*) *haueri arioni*. B – Bivalves (mainly *Zamphiridacna* taxa) enclosed in the Upper Dacian deposits at Scheiu (Photos Adrian Popa and Adrian Gherghe).

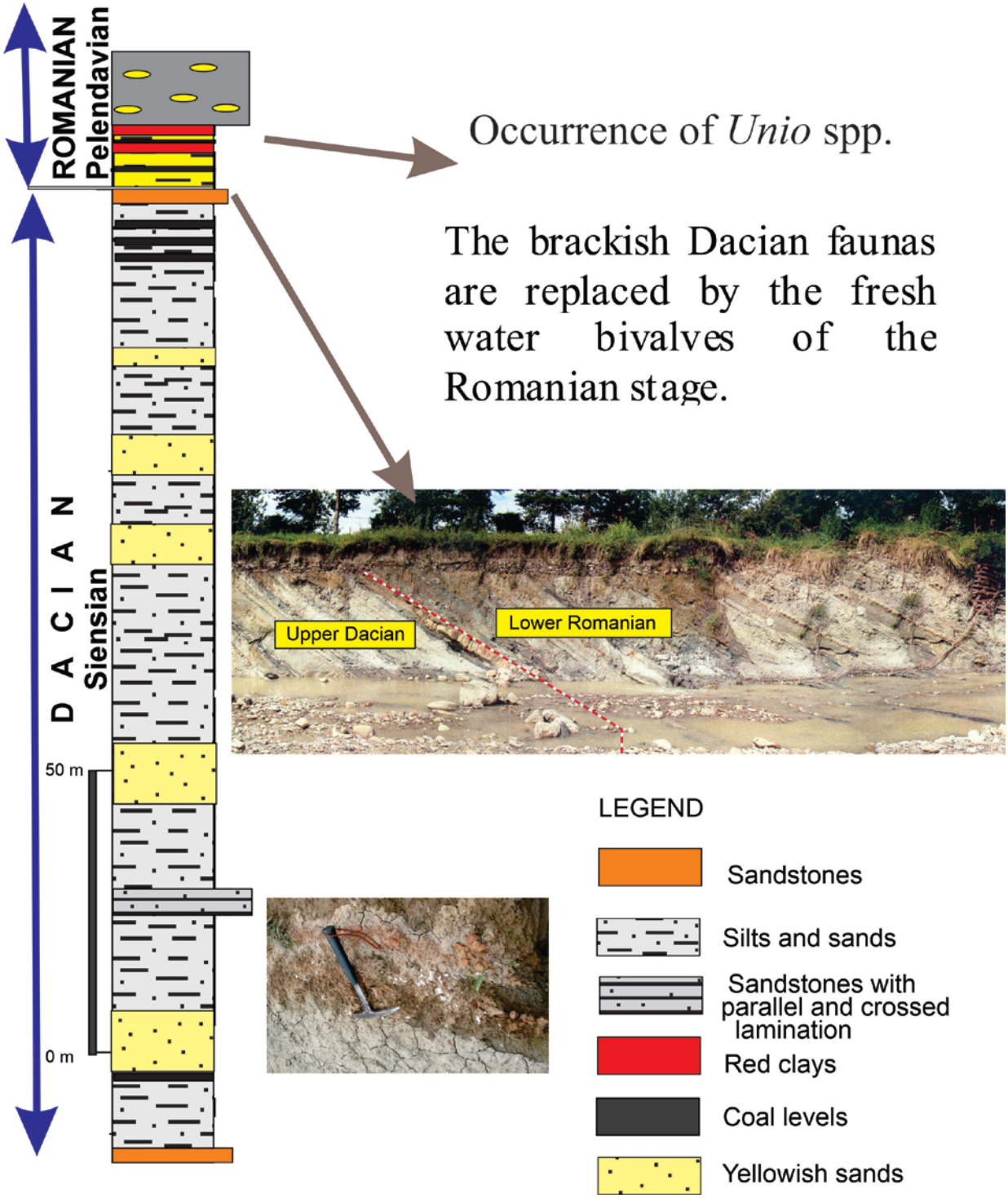
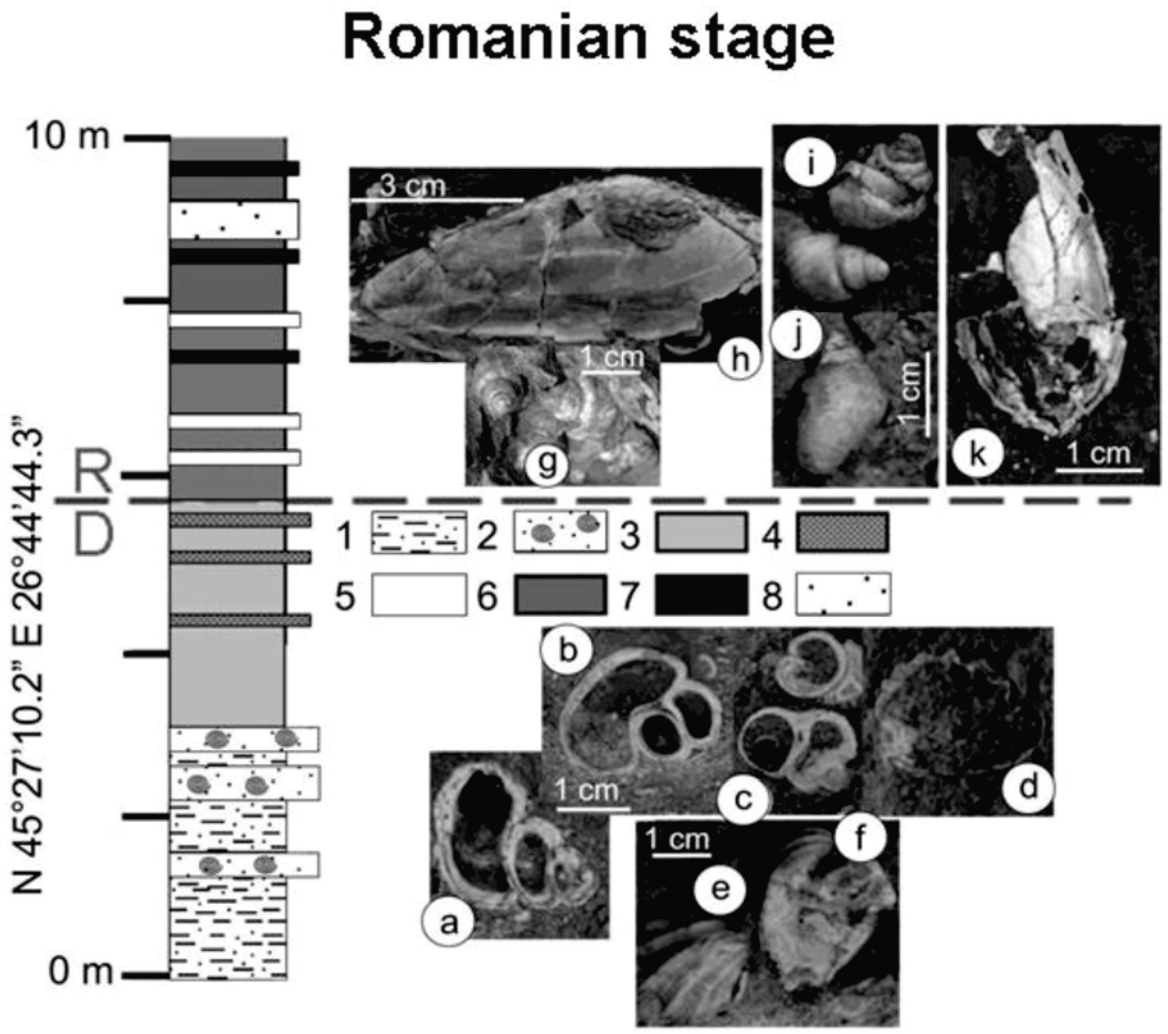


PLATE 36 – The Romanian parastratotype exposed at Scheiu on the Slănicul de Buzău left bank (Dacian substages after Andreescu, 2008 – *Magnetostratigrafia depozitelor sarmato-pliocene din estul Bazinului Dacic*. In: Avram C. & Melinte M.-C. (coord.) Pal;eoambianțe și paleodiversitate în contextulschimbărilor climatice, p. 5-116, Edit. Eikon, Cluj-Napoca) (Photo Mihaela Melinte-Dobrinescu).



Litho- and biostratigraphy of the Romanian stage in the Slanicul de Buzau Valley; D = Dacian stage; R = Romanian stage. Lithology: 1. Grey clays; 2. Yellowish fossiliferous massive sandstone; 3. Clays interbedded with thin sandstones; 4. Sandstones; 5. Grey coarse-grained sands with poorly preserved macrofaunas; 6. Grey silts interbedded with coarse-grained sands; 7. Lignite beds; 8. Sands with unionids.
Macrofaunas: a. *Viviparus* sp.; b, c. Gastropods (sections); d. Limnocardiids (section); e, f. *Prosodacna* (*Psilodon*) *stefanescui euphrosinae*; h. *Jazkoa sturdzae*; g. Coquinas with viviparids; i. *Viviparus bifarcinatus bifarcinatus* (BIELZ); j. *Lithoglyphus* (?) sp.; k. *Unio* (*Rumanunio*) sp.

PLATE 37 – Litho- and biostratigraphy of the Dacian-Romanian boundary interval exposed at Scheiu, Slănicul de Buzău Valley (Photos Mihaela Melinte-Dobrinescu, Titus Brustur and Andrei Briceag).

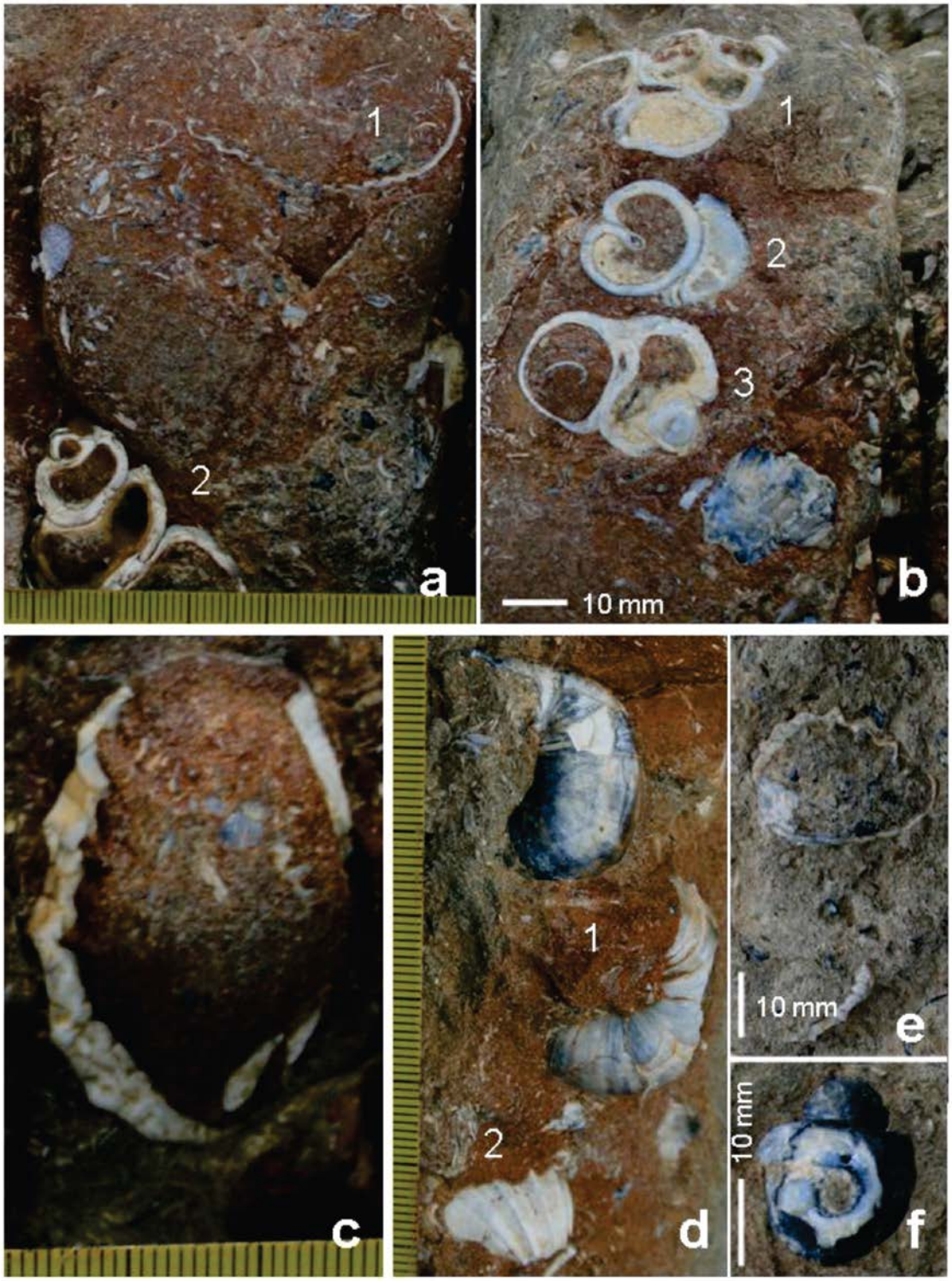


PLATE 38 – Macrofaunas at Scheiu (upper part of the Dacian): *Zamphiridacna*– tangential sections (a1), molds (c), *Limnocardium*– tangential sections (e), spire fragments and apical sections of *Viviparus* (a2, d1, f), *Pachydacna* (d2), tangential sections of *Viviparus* (a2, b), *Limnocardium* (*Tauricardium*) sp. (c, d), *Prosodacna* (*Psilodon*) aff. *haueri* (e) (Photos Titus Brustur).

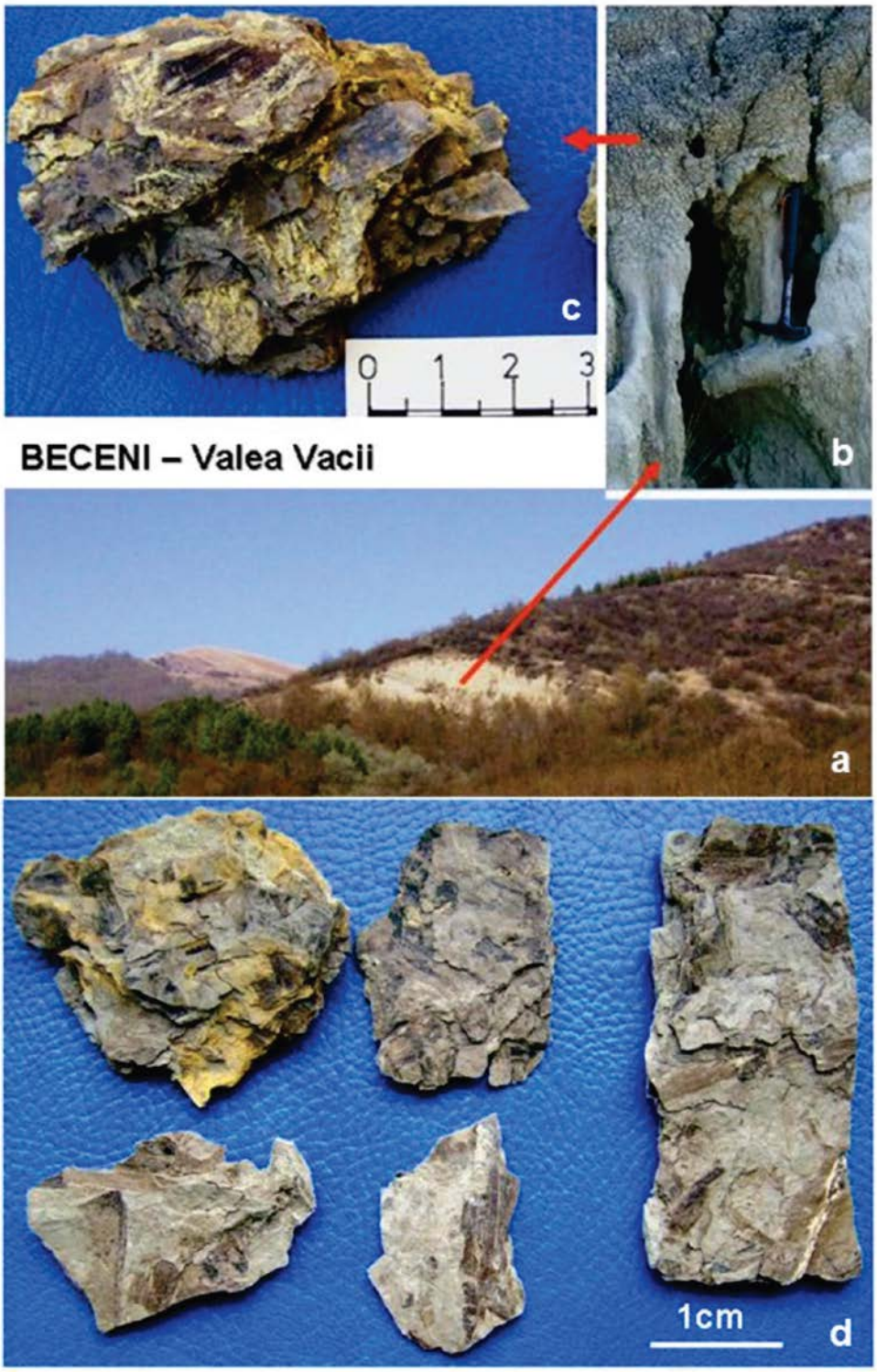


PLATE 39 – Secondary gypsum cropping out at Valea Vacii, near the Beceni locality (Photos Titus Brustur).

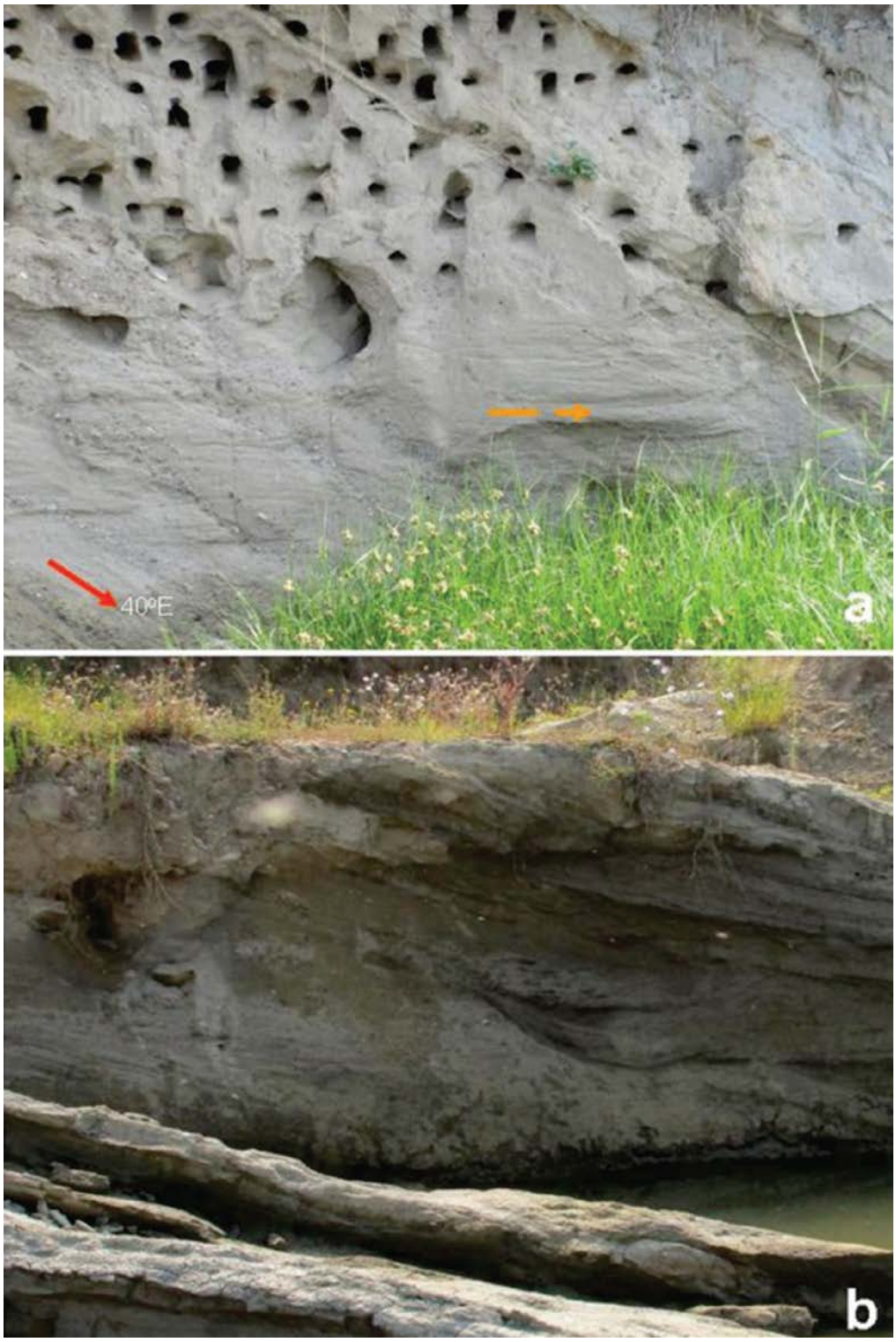


PLATE 40 – Deposits of the alluvial Cândeşti Formation cropping out in the Buzău River basin (Photos Titus Brustur).

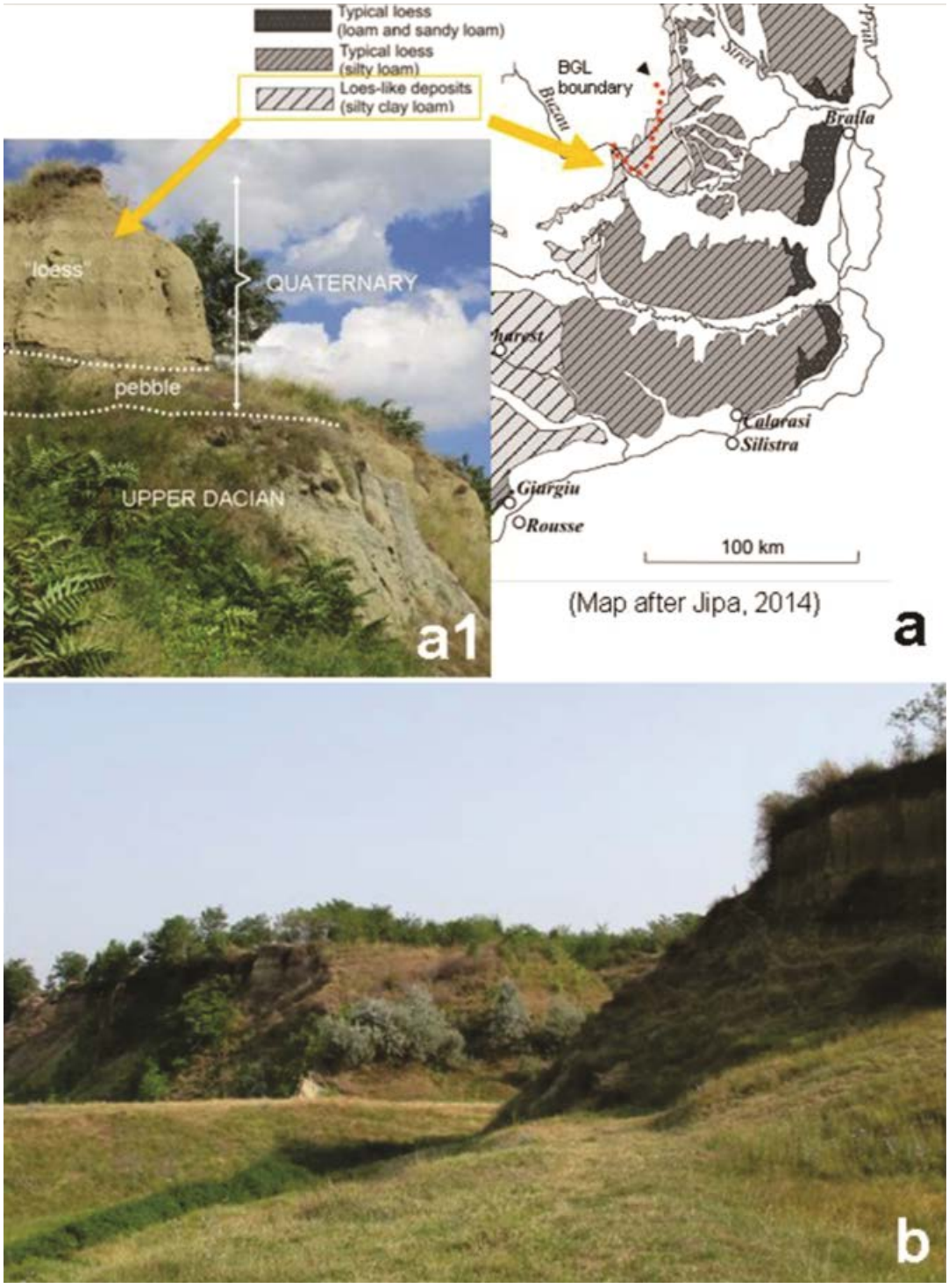


PLATE 41 – Loess deposits exposed in the Buzău Valley basin (Photos Titus Brustur).

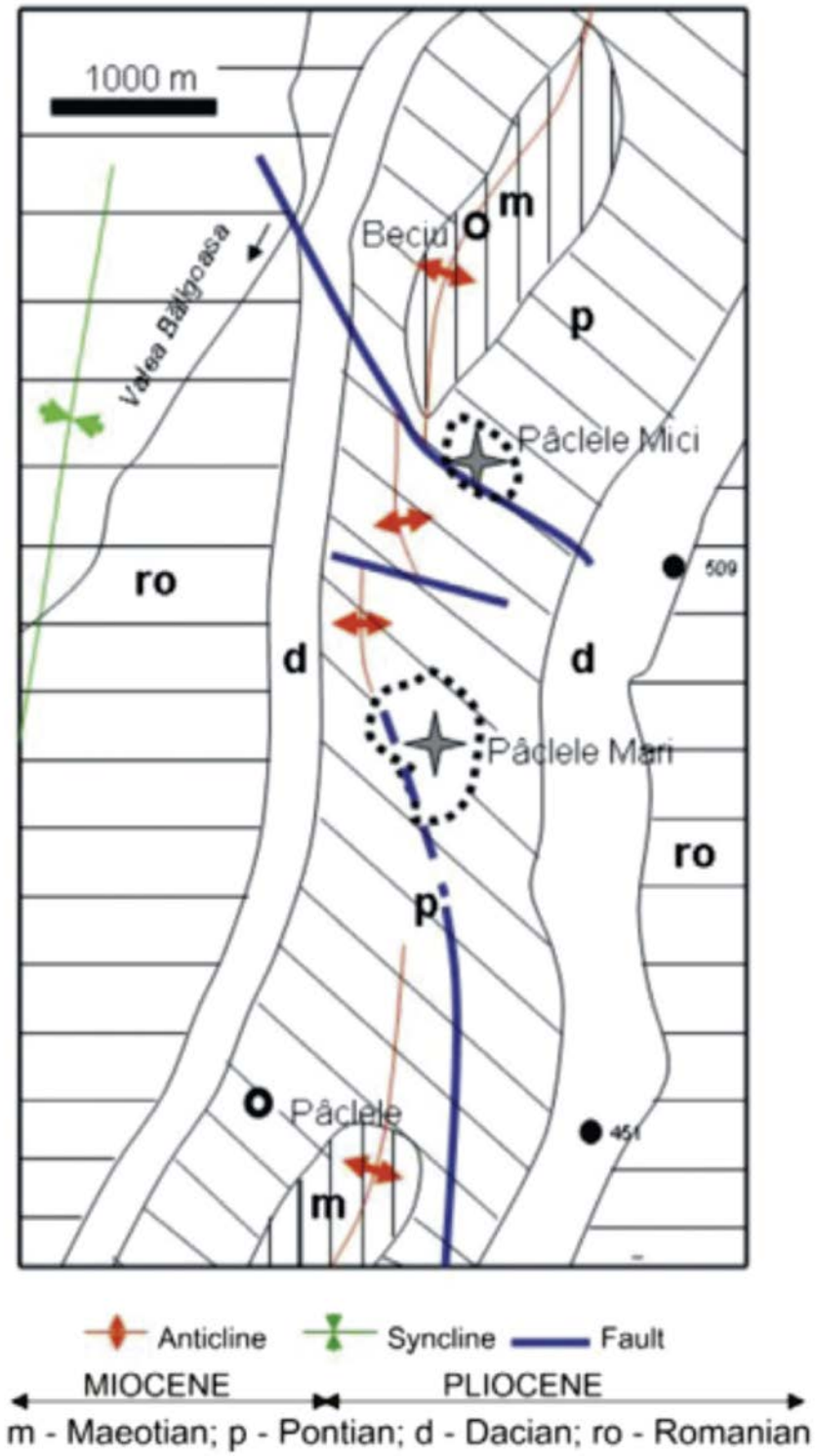


PLATE 42 – Geological map of the Berca region, with the location of mud volcano structures, from Ciocârdel (1949).

PLATE 43 – Beciu Mud Volcano plateau (Photos Andrei Briceag).

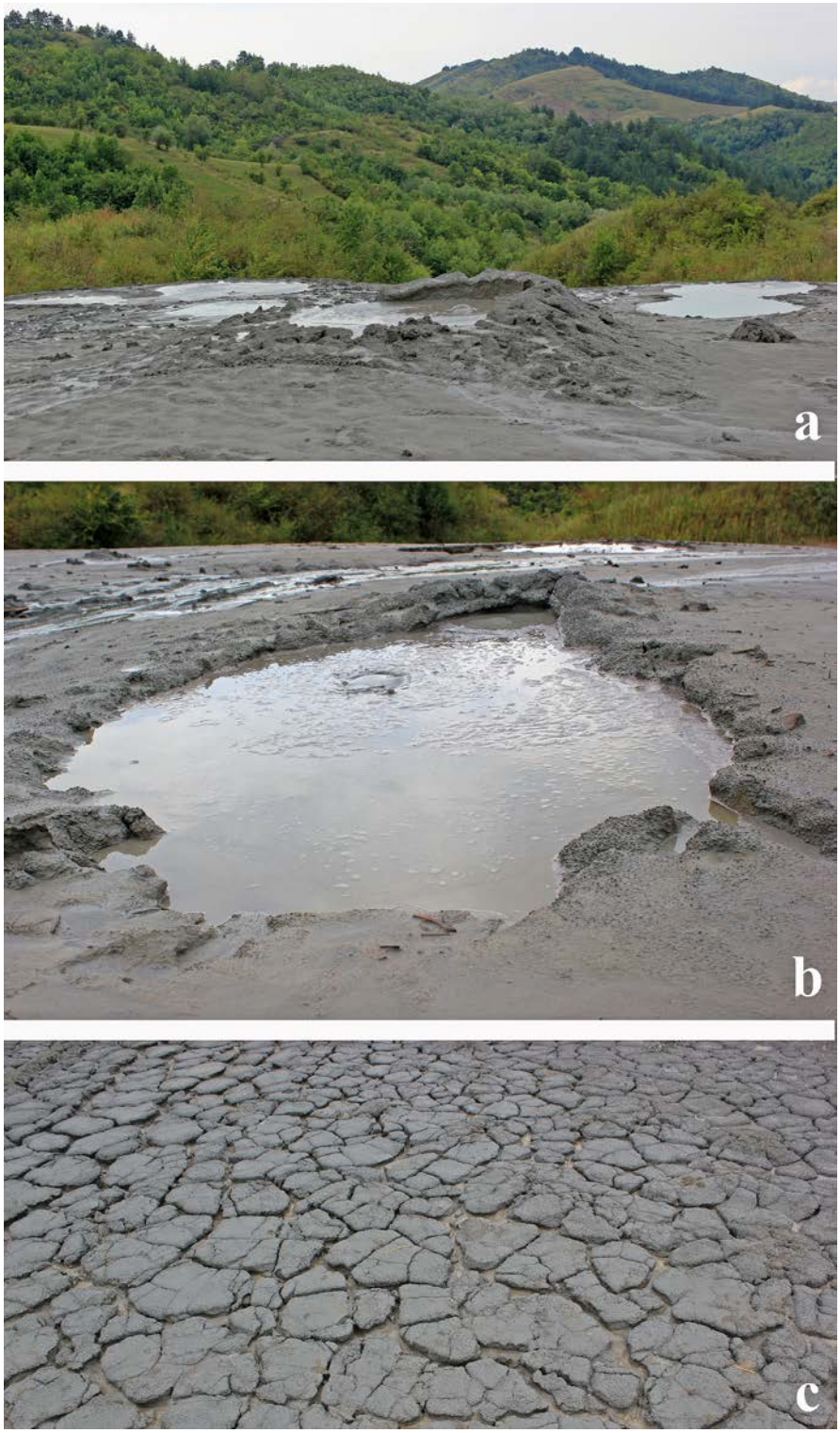
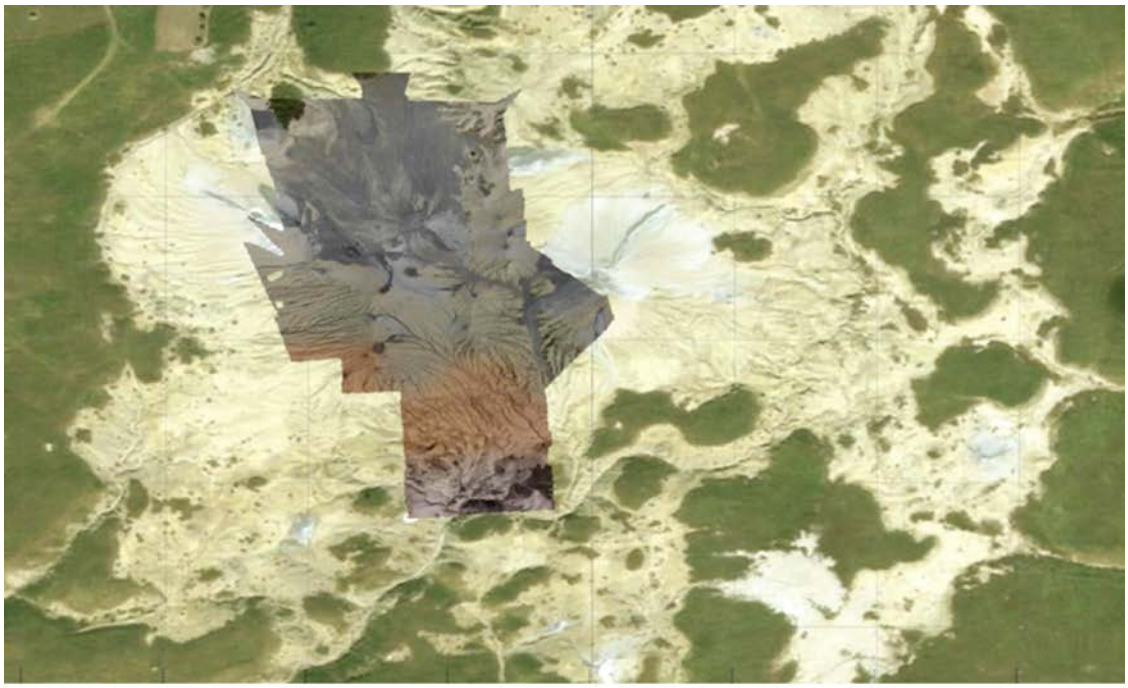


PLATE 44 – Mud cones of Beciu Mud Volcano (a, b) and polygonal drying cracks (c) (Photos Andrei Briceag).

PLATE 45 – Calderas of crude oil and mud surrounded by a salty soil at La Fierbători Mud Volcano (Photos Gabriel Ion).



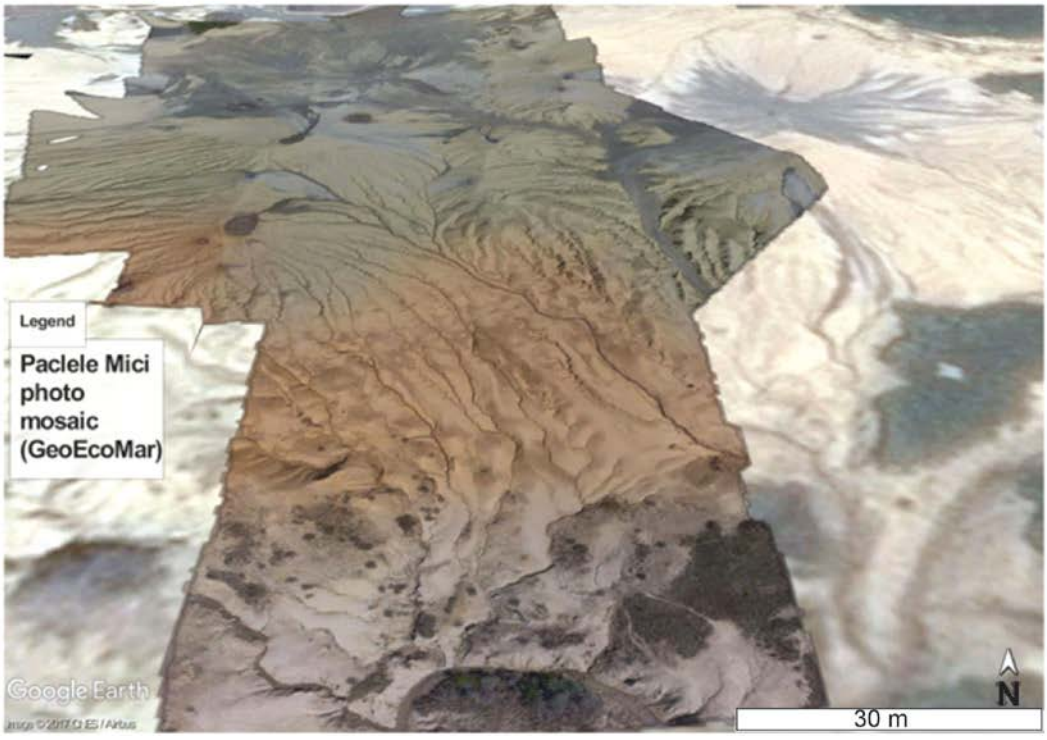


PLATE 46 – Above: Photo-mosaic made of UAV pictures draped on Google satellite images at Pâclele Mici Mud Volcano plateau; Below: Detail of the above mentioned photo-mosaic, mud cones are depicted (Photos Gabriel Ion).

PLATE 47 – Pâclele Mici Mud Volcano. a: Small cones; b: ejected mud; c: mudcracks (Photos Mihaela Melinte-Dobrinescu and Titus Brustur).

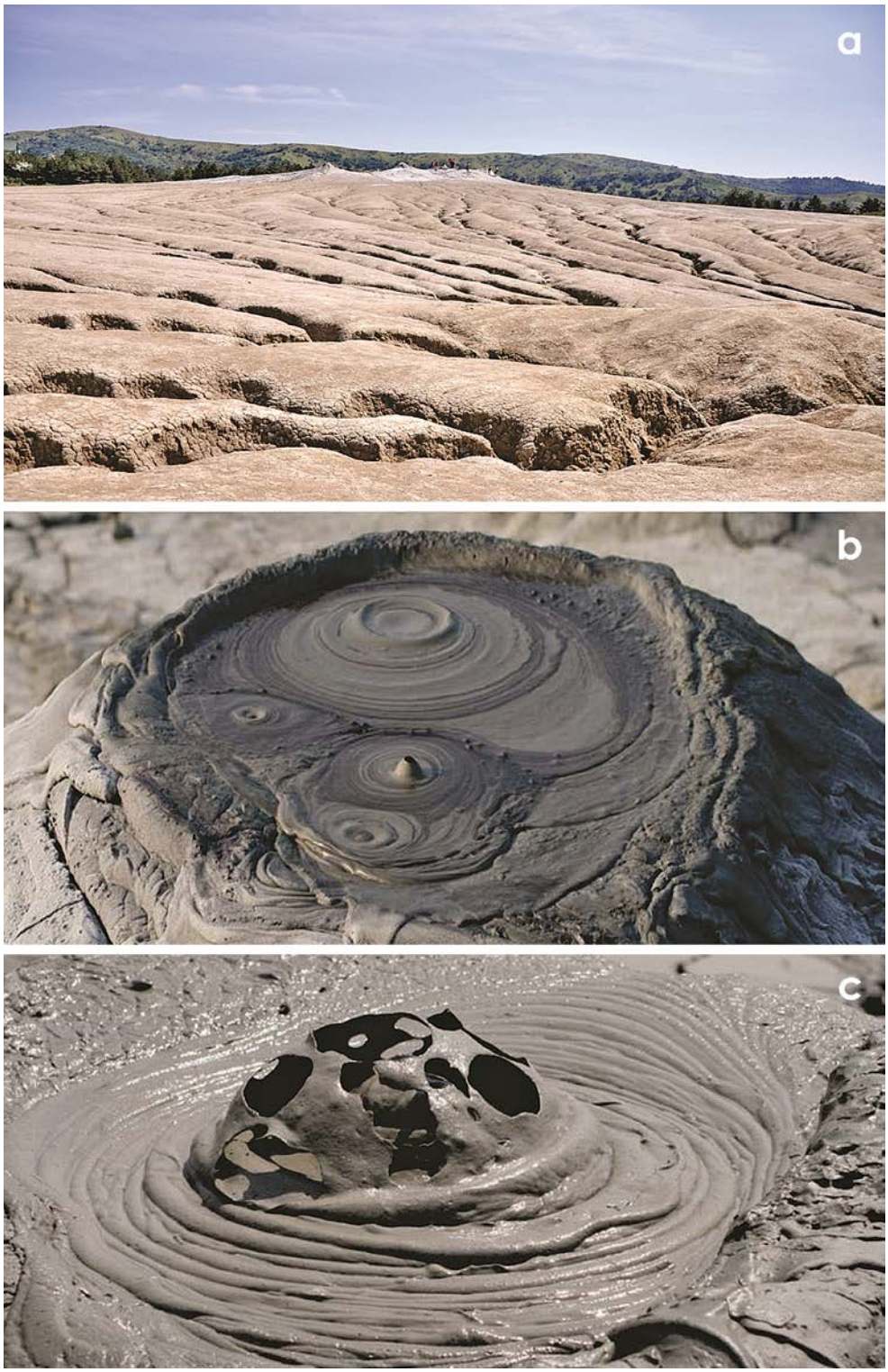


PLATE 48 – Pâclele Mici Mud Volcano. a: edge of the plateau with dried mud; b, c: mud bubbles (Photos Ştefan-Andrei Szobotka).

PLATE 49 – Cones, bubbles and calderas at Pâclele Mari Mud Volcano (Photos Titus Brustur and Ștefan-Andrei Szobotka).

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This work was financed by the Ministry of Education and Research through the Project 8PFE FLUVIMAR (Research of Excellence in Ancient and Modern River-Delta-Sea Systems) and the Programme Nucleus of INCD GeoEcoMar, Project No. 19 20 05 02.

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ISBN 978-606-9658-02-4