THE MIOCENE FROM BUZĂU AREA

A GEOLOGICAL AND GEOCONSERVATION PERSPECTIVE

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Revised version with supplementary data of the *"Neogene deposits in the South-Eastern Carpathians- Field Trip Guide"*, by Marius Stoica, Mihaela C. Melinte-Dobrinescu and Dan Palcu, 2012

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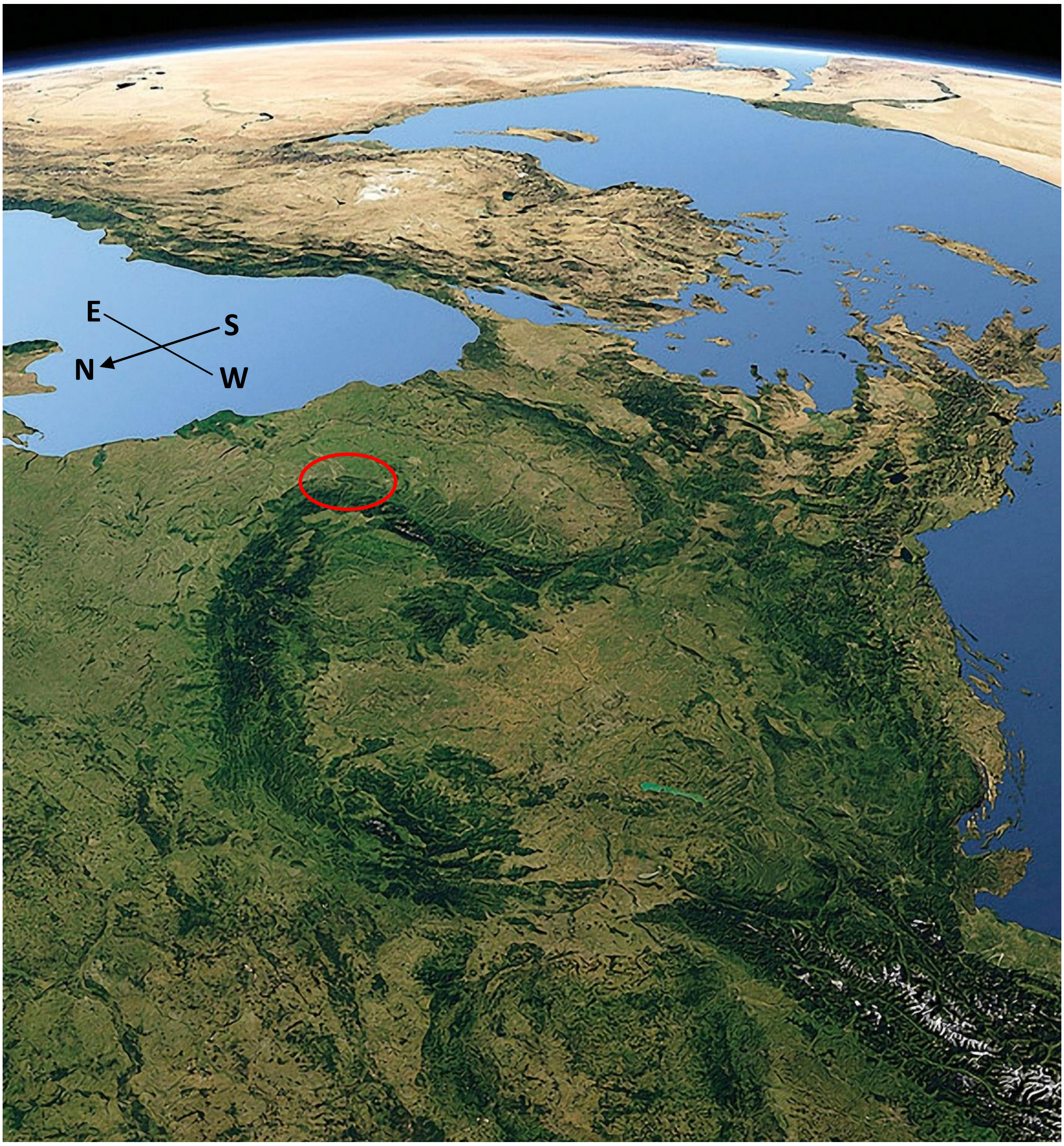


Fig. 1. A different look on the Carpathians. South-eastern Europe seen from an unusual perspective. Greece on the upper right with the Mediterranean Sea behind. On the upper left the Black Sea and Turkey. In the center of this view the bow of the Carpathian Mountains can be seen. Copyright © Cristoph Herman, http://earth.imagico.de/.

GEOLOGY OF THE CARPATHIANS

The Carpathians are an Alpine Orogen, the eastward continuation of the Northern Alps (Fig. 2). Similar to the Alps, the Carpathians record the closure of the Alpine Tethys. In the case of the Carpathians, this spans from the Latest Jurassic to Middle Miocene.

The Mesozoic deformations of the Carpathians are characterized by strong basement involved thrusting (e.g. Dacia, East Vardar, Ceahlău-Severin). These basement nappes outcrop in the western part of the Eastern Carpathians (Bucovinian nappes), the South Carpathians (Getic nappes), and from the basement of the Transylvania Basin (Fig. 2, 3).

OVERVIEW

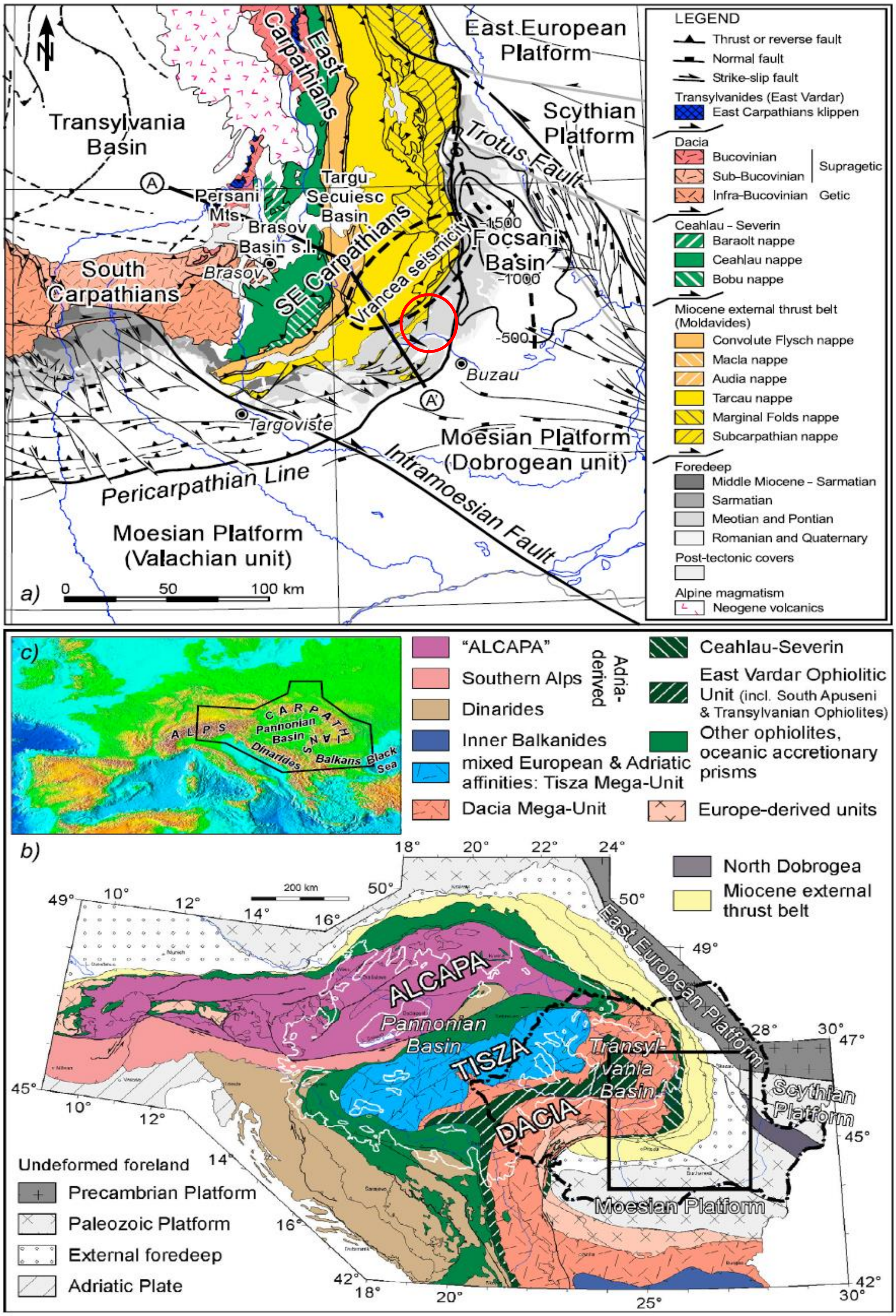


Fig. 2. Tectono-structural maps of the Carpathians Bend Zone from Merten et al. (2010). Solid black line marks the A-A' cross section of Fig. 3. The red circle stands for the field trip area.

OVERVIEW

The Cenozoic deformations of the Carpathians are recorded by „thin-skinned“ nappes (Fig. 2) as the remnants of the Alpine Tethys and are subducted under the Carpathians to the west. The thin-skinned nappes comprise sediments scraped off from the subducting plate during several thrusting phases, as follows: Cretaceous (Ceahlău nappe), Late Oligocene – intra-Burdigalian (Black-Flysch, Audia, Macla, Tarcău nappes), and Middle Miocene (Tarcău, Marginal Folds, and Subcarpathian nappes). The total amount of shortening observed in the „thin-skinned“ nappes and estimated based on balanced cross-sections varies from 150 to 500 km.

The most recent deformation stage of the Carpathians, referred to as the Vallachian stage, is Pliocene to Recent in age (Fig. 3). This deformation is not related to the subduction process, because it post-dates the orogen collision. Instead, the Vallachian stage has been interpreted as the result of intra-Carpathian compressional forces evident also on the present-day stress measurements. This intra-plate compression was accommodated by lithospheric-scale folding due to the strong post-collisional foreland coupling between the upper and lower plates. In the SE Carpathians, the lithospheric-scale folding resulted in 2-3 km of uplift and erosion in the core of the orogen, out-of-sequence reactivation of older thrust planes, and inversion of Mesozoic grabens on the lower plate.

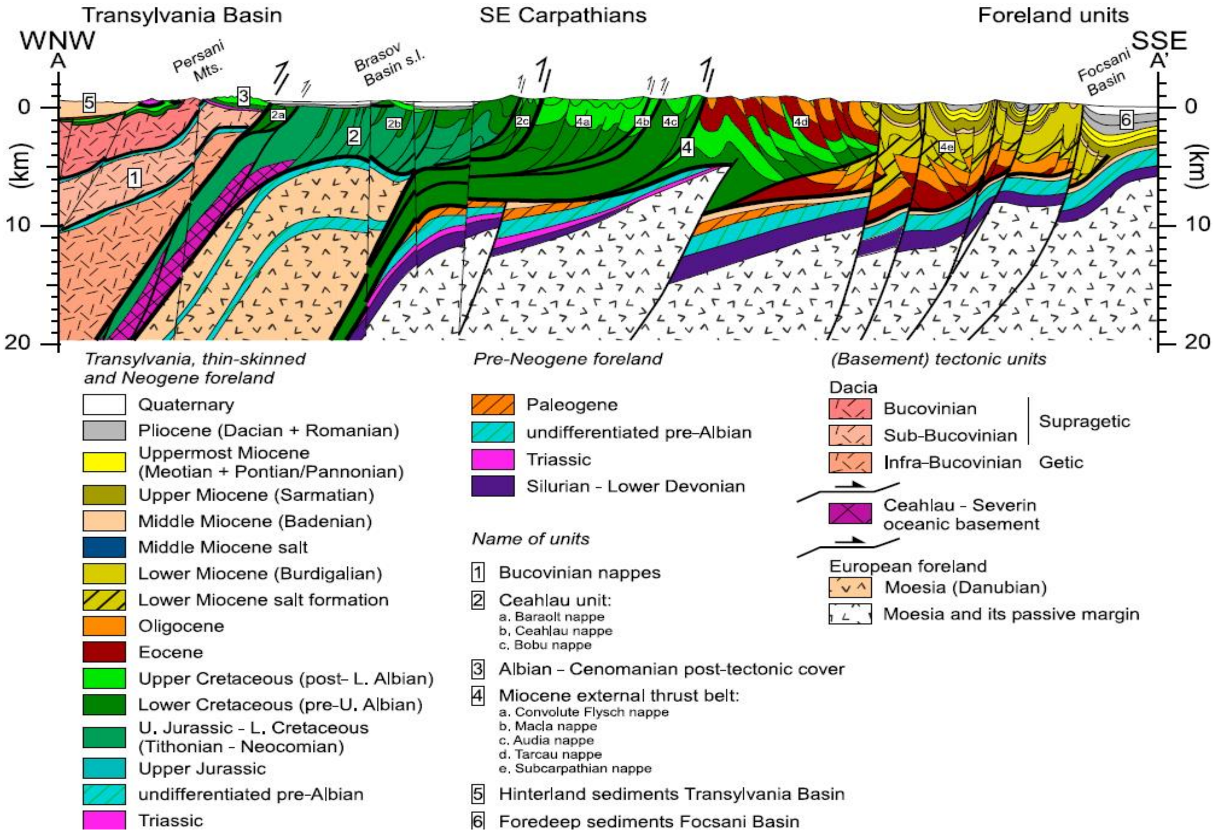


Fig. 3. Transect A-A’ (shown on Fig. 1) across the Carpathians Bend Zone from Merten et al. (2010). The section illustrates the Cretaceous basement nappes of the internal Carpathians (“Dacia”, to the west) and the thin-skinned outer (external) Carpathians (to the east).

THE EASTERN CARPATHIANS

The Eastern Carpathians represent an important segment of the Romanian Carpathians that develop between the Tisa Valley to the North and Dâmboviţa Valley to the South. On a distance as long as 600 km a mountainous chain, with peaks higher than 2,000 m, rises. The Eastern Carpathians are located between the Transylvanian Depression (westwards), The Moldavian Plateau (eastwards) and the Romanian plain (southwards).

OVERVIEW

From a geological point of view, the Eastern Carpathians chain consist of a nappe pile made up of basement nappes in the western part, and Early Cretaceous pelitic marine deposits, Late Cretaceous to Palaeogene flysch deposits, as well as Miocene to Quaternary molasse deposits, in the central and eastern parts. Imbrication and internal deformation of the nappes took place in several periods of deformation from the Late Cretaceous to Quaternary.

Based on the age of the main deformation and the mutual areal position, the following tectonical units were recognized (Săndulescu, 1988): the Pienids, the Transylvanian Nappes, the Median Dacides (Central East Carpathians Nappes), the Outer Dacides, the Inner Moldavids and the Outer Moldavids (Fig. 3).

The Moldavian realm developed in Hauterivian-Albian times as Euxinic basin, characterised by the deposition of rich-organic black shales (Roban and Melinte-Dobrinescu, 2012). The Mid-Cretaceous tectonic movement determined an important deepening in the Moldavid basin. Hence, sediments deposited in the marine red bed facies (Melinte-Dobrinescu and Roban, 2011) accumulate below or close the CCD. During the Late Cretaceous (i.e., Senonian), the turbidite sedimentation covered the main part of the Moldavid basin; hence, different turbidite sequences, such as sandy flysch, shaly flysch or calcareous ones, were sedimented (Săndulescu et al., 1980; Săndulescu, 1994).

Within Palaeogene times, the turbiditic sedimentation reached the largest areal development, showing also the most complex lithological diversity. A peculiar facies developed in the Oligocene-Early Miocene interval in the outer part of the Molavid basin, covering the West Tarcău Nappe, the Vrancea Nappe and the Subcarpathian Nappe, made by bituminous rocks and massive quartz sandstones, namely the Kliwa Facies. This facies coexists with innermost Outer Moldavide flysch sediments of the Fusaru-Pucioasa facies, supplied by an inner, Carpathian, source area (Ştefãnescu and Melinte, 1996). Additionally, transitional zones between the two above-mentioned facies could be observed.

In the Burdigalian, an evaporitic (salt and/or gypsum) event marks the end of the turbiditic deposition in the inner part of the Moldavides and of the hemipelagic (bituminous facies) in outer structures.

This event was followed, within the Late Burdigalian-Early Badenian interval, by the deposition of thick molasses and schlier deposits in the Tarcău, Vrancea and Subcarpathian nappes. A second evaporitic event took place within the Middle Badenian, followed by the sedimentation of Upper Miocene-Pliocene coarse grained and sandy molasses (Săndulescu, 1984), restricted to the Subcarpathian Nappe and, mainly to the foredeep.

THE DACIAN BASIN

The Dacian Basin was the smallest marine component of the Paratethys realm (Fig. 4). Located between the Euxinian and the Pannonian basins, the Dacian Basin was in communication with its neighbours. The connection with the Euxinian Basin was permanent and is clearly shown on the paleogeographic maps (Hamor, 1988, Rögl, 1998, Popov et al., 2004). The communication relationship with the Pannonian Basin is indirectly revealed, by bio-geographic ways, and so far the connecting ways and their location are only presumed.

The final configuration as a distinct paleogeographic unit of the Dacian Basin dates from the latest Sarmatian s.l. Paratethyan stage (Saulea et al., 1969), at about 10-11 Ma. The Dacian Basin was the last vestige of the Carpathian foredeep. In the course of time, beginning from the Badenian stage, the foredeep shrinked through the southward migration of its northern border. The Dacian Basin represents the result of this process. Due to the continental collision between the East European-Scythian-Moesian foreland and the Tisza-Dacia block (Balla, 1987) during the Late Sarmatian, the mountain chains around the Dacian Basin uplifted. This started the erosion process in the Dacian Basin

OVERVIEW

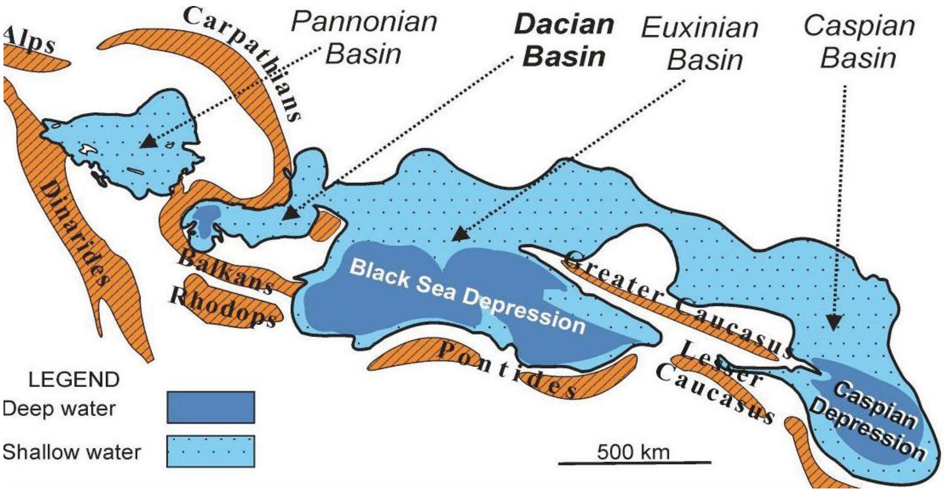


Fig. 4. The setting of the DacianBasin within the Paratethys (from Jipa and Olariu, 2012).

sediment source-areas, and substantially contributed to the outlining and sediment supply of the sedimentation areas in the basin.

In the Late Sarmatian s.l., around 10-8.5 Ma, the Dacian Basin was in the stage of large areal opening toward the Euxinian Basin (Fig. 5). Since the Maeotian stage (8.6-8.2 to 6.0 Ma – after Vasiliev et al., 2004; Krijgsman et al., 2010), the marine communication with the Euxinian Basin became narrower. Connected to the Black Sea Depression by the Galaţi sea-way, on the palaeogeographic maps the Dacian Basin appears as a semi-enclosed sea.

During its entire evolution the Dacian Basin was exposed to large scale areal changes (Jipa and Olariu 2009). The modifications occurred by the southward shifting of the northern and southern basin boundaries. The effect of these changes was moderate, and did not inflict major areal alterations.

Different authors described the Dacian Basin as a “sea” or a “lake”, without any proper explanation. The most important criterion to classify the Dacian Basin as a sea or a lake is the fact that, during its whole existence as a water body, it was permanently in communication with the Oriental Paratethys (Euxinian and Caspian basins), a large intra-continental, brackish marine body. Based on this connection, but taking into account also other features, Jipa and Olariu (2009) consider the Dacian Basin a land-locked brackish marine body.

Very low water salinity values were recorded in sediments accumulated in the last stage of the Dacian Basin existence. This is normal for a marine basin without connections with normal salinity marine basins, a situation experienced by the entire Paratethys domain during the Sarmatian s.l. up to the Dacian interval (Rőgl, 1998). Moreover, the paleontological data, on which the water salinity evaluation relied, comes from sediments accumulated in littoral waters, exposed to the influence of continental fresh water inputs.

Since its closure the Dacian Basin formed a distinct source-to-sink system, within the southern part of the Carpathian chain (Fig. 4). The Balkans and the Dobrogea highland had a minor participation to this system.

As a consequence of the Carpathian uplift, during the Late Sarmatian s.l. tectonic climax, the main sediment source-areas of the Dacian Basin came into being. The Carpathian uplifting was not uniform. Higher elevation relief formed only in the southern part of the Eastern Carpathians and in the western Southern Carpathians (Sanders et al. 1999). In this way, two major source-areas appeared: the Eastern Carpathians (southern part) and the Southern Carpathians (western part) source-areas. A smaller high relief area, outlined by Sanders et al. (1999) in the central-eastern part of the Southern Carpathians, also acted as source-area (Jipa and Olariu, 2012).

OVERVIEW

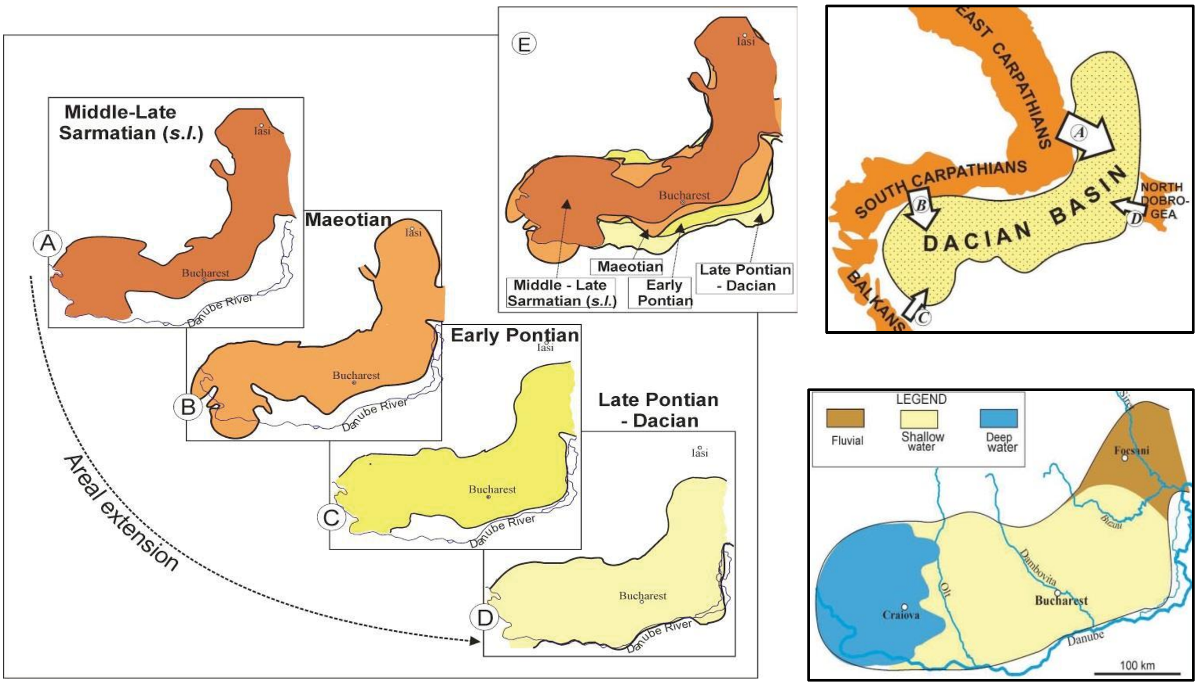


Fig. 5. Areal evolution of the Dacian Basin sediment accumulation in the Late Neogene. The SW limit of the Dacian Basin after Hamor et al. (1988). A to D: the progressive shift of the southeastern boundary of the basin, from Late Sarmatian (s.l.) to Late Pontian (modern Danube River course for marker); right-up corner (E): superposed maps to make evident the time-continuous enlargement of the Dacian Basin; top right corner: source areas of the Dacian Basin sediments: A – The Eastern Carpathians source area; B – The Southern Carpathians source area; (from Jipa and Olariu, 2009); bottom-right corner: the Dacian Basin physiography and environmental setting (from Jipa and Olariu, 2012, simplified after Saulea et al., 1969).

Besides the Carpathian area, the Dacian Basin received detrital material from the Balkan and the Dobrogean source areas (Fig. 5). The evaluation of the sedimentvolume in different zones of the Dacian Basin and at succeeding time spans (Jipa and Olariu, 2012) pointed out that the most detrital influxes came from the Carpathians, and only a small part from the Balkan and Dobrogean areas.

Under the influence of the active Eastern Carpathian source-area, the northern extremity of the Dacian Basin was an almost permanent fluvial sedimentation zone (fig. 5). At the opposite terminal part of the basin, in its western part, from the end of the Sarmatian s.l. (between 8.6 and 8.2 Ma) to the Middle Pontian (5.8-5.5 Ma) a deep-water depression (around 300 m) developed (Tarăpoancă, 2004; Jipa, 2009; Jipa and Olariu, 2012; Leveer et al., 2010). The largest part of the Dacian Basin marine area functioned as a shallow water environment. Judging by the thickness of the deltaic bodies occurring in this zone, the water depth was 100 m or smaller (Jipa and Olariu, 2012). The water could have been slightly deeper south of the deltaic area.

During the Upper Pontian the deep water depression representing the western depocenter of the Dacian Basin was in advanced stage of sediment filling. Towards the end of the Pontian stage, i.e. 5 Ma, its accommodation space was consumed. In the eastern depocenter, maintained active by subsidence, the accommodation space became exhausted later, i.e., at the end of the Dacian time (4 Ma). The Dacian Basin closure evolved progressively, through the eastward shifting of the shoreline (Jipa et al., 2007; Jipa and Olariu, 2012). The final fill-out stage took about 700,000 years. Starting from the Romanian time the entire Dacian Basin area, previously a brakish marine environment, grew into a continental territory, with fluvial system environments.

OVERVIEW

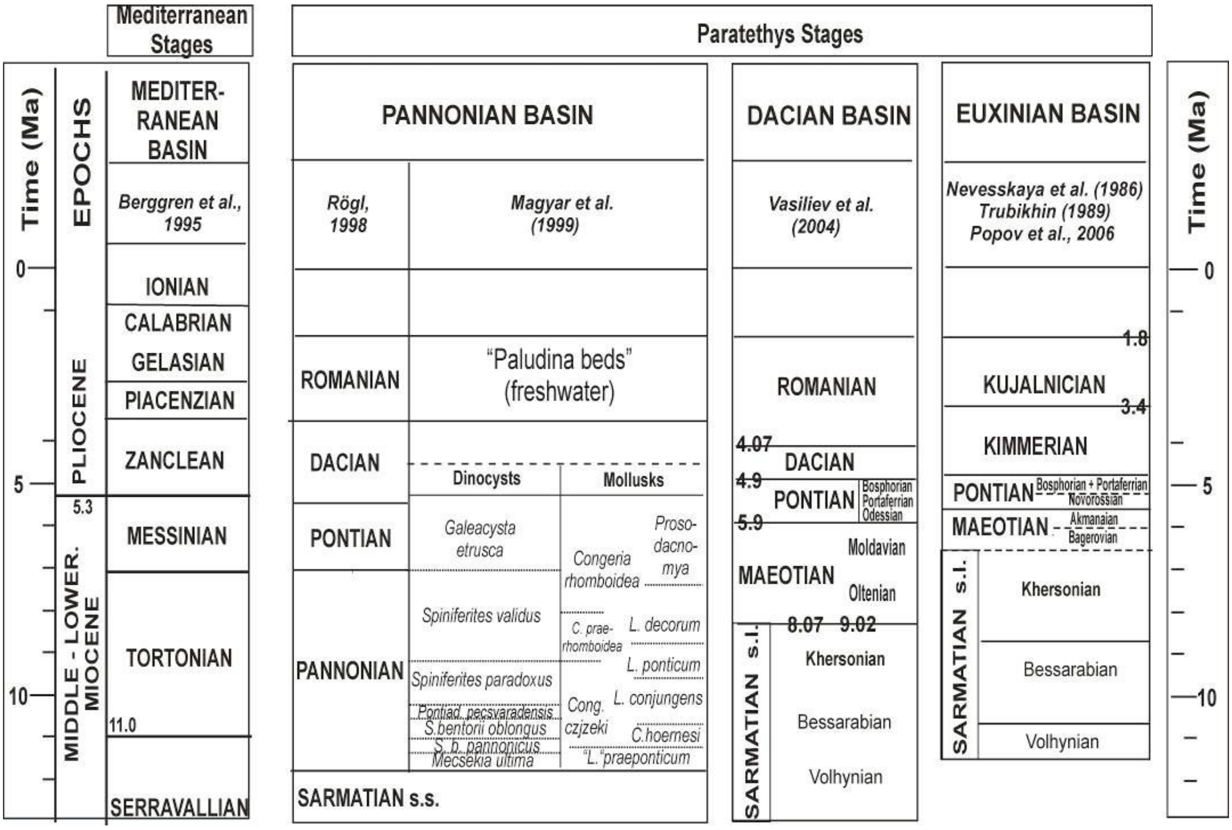


Fig. 6. Correlation of the Middle-Upper Miocene to Lower Pliocene Mediterranean stages with Regional Paratethyan stages (from Jipa and Olariu, 2009).

During the Upper Sarmatian s.l. – Dacian interval, comprises between 11 and 4 Ma, the Dacian Basin was a low salinity, epicontinental sea, with fairly continuous sedimentation. The Palaeo-Danube River appeared in the Dacian Basin area after the basin closure (later than 4 Ma), when the basin territory became a fluvial sedimentation area.

The stratigraphic hiatus from the southern area of the Dacian Basin served as argument for Clauzon et al. (2005) to maintain that the Palaeo-Danube appeared as a consequence of the Messinian crisis. The southern Dacian Basin gap is a non-erosional feature, which have nothing in common with the Palaeo-Danube or with the Messinian crisis (Jipa, 2009).

DAY ONE

Field trip stops

The field trip starts from Bucharest, situated in the Moesian Platform, one of the most developed tectonic units in Romania, occupying all the southern and eastern parts, till the Black Sea. From Bucharest as far as the Ploieşti town, situated 60 Km to the N, the Moesian platform and the outer zone of the Neogene Foredeep, superposed on it, are crossed. Morphologically, the area is part of a large plain, the Romanian Plain that spread between the Danube, to the S, and the Subcarpathian hills, towards N. In the NE vicinity of the Ploieşti city, the southernmost hills of the Subcarpathians correspond to anticline structures of the inner zone of the Foredeep, namely the Bucov and Boldeşti anticlines, which are oil-bearing structures (Middle Miocene reservoirs). North of the Boldeşti Anticline, marked by a more flat morphology, the Măgurele Syncline developed. The youngest deposits, the Cândeşti Formation made mainly by gravels, are of Early Pleistocene in age (Săndulescu, 1988), being the youngest unit deformed by the Wallachian tectonic phase.

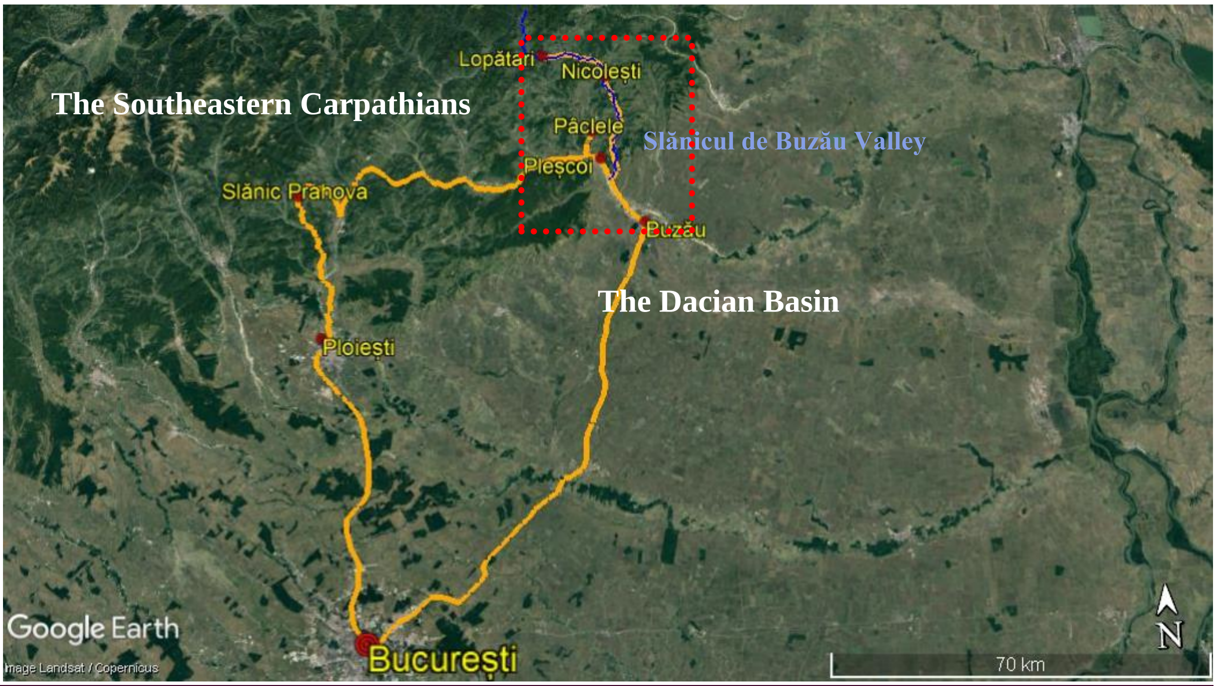


Fig. 7. Route map. We leave Bucharest to the N, drive to Ploieşti and then to Slănic Prahova. We will drive thereafter to Berca and then to Mud Volcanoes at Pâclele. On the second day we will drive upstream along the Slănicul de Buzău Valley until Lopătari. We will spend most of the day in this valley, travelling downstream. Source: Google Earth.

Day 1

Most of the stops of the first day are placed around the Slănic-Prahova and Vălenii de Munte towns, located in the Prahova County, at 45 km NE of the Ploieşti city (Figs. 7, 8a, b) and 110 km far from Bucharest, the capital city of Romania. For the last stop we shall cross to Buzău Valley north of Berca to visit the Mud Volcanoes at Pâclele Mici.

Stop 1 - Middle Badenian evaporitic formation in the Salt Mountain.
Stop 2 - Middle Badenian salt mine.
Stop 3 - Lower-Middle Badenian tuff and ”Globigerina marls” in the ”Piatra Verde” -The Green Stone hill.
Stop 4 - The Middle Badenian Evaporitic Formation north of Slănic Prahova.
Stop 5 - Lower Miocene gypsum at Slon.
Stop 6 - Mud Volcanoes at PâcleleMici.

DAY ONE

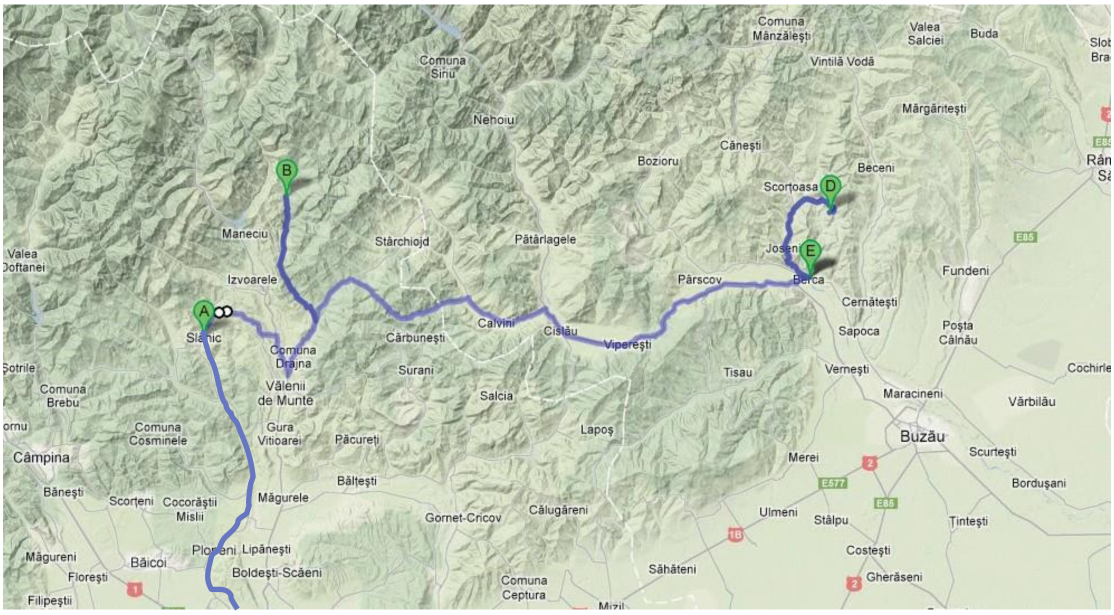


Fig. 8a. Plan of the field trip route of the 1st day: A - Slănic (Stop 1 - Middle Badenian evaporitic formation in the Salt Mountain, Stop 2 - Middle Badenian salt mine, Stop 3 - Badenian tuff and ”Globigerina marls” in the ”Piatra Verde” - The Green Stone hill, Stop 4 - The Middle Badenian Evaporitic Formation north of Slănic Prahova), B – Slon (Stop 5 - Lower Miocene gypsum), D - Pâclele Mici (Mud Volcanoes), E - Pleșcoi (accommodation). Copyright © www.googlemaps.com.

From geological point of view, Slănic - Prahova is situated towards the southern end of the Tarcău Nappe, the most developed tectonic unit of the Moldavides (Outer Flysch Zone of the Eastern Carpathians). Towards Prahova County, this nappe ends in two main anticlines, namely Homorâciu and Văleni, which are separated by two synclines, Slănic and Drajna, both filled with Miocene molasse. The post-tectonic sedimentary cover of TarcăuNappe are made by molasse formations, such as the Doftana Formation that started to be accumulated in Early Miocene times, i.e. Burdigalian and, respectively Eggenburgian, in terms of the Paratethyan stages (Ştefănescu and Mărunţeanu, 1980), followed by the Slănic Formation s.l., Middle Miocene in age (Popescu, 1987; Papaianopol and Mărunţeanu, 1992; Marinescu et al., 1998).

A representative succession (Popescu, 1951) of the Badenian deposits from Outer Moldavides (Tarcău Nappe) is exposed in the axial part of the Slănic syncline (Fig. 8b), north of the Slănic- Prahova locality. The Slănic syncline appears as a normal fold, pitching to NW, with asymmetric flanks: the SE one is sharply inclined, opposed to the NW one. The whole syncline is fragmented by longitudinal and transverse faults. The salt appears as a lens-like accumulation, with widest thickness in its central area (499 m). In the central-north area, there is a slight diapiric tendency, due to the lateral pressure developed by the Homorâciu anticline. It consists of several units (from older to younger):

(i) **The Slănic Formation**s.s. (i.e.,firstly described as the Slănic Tuff), composed of volcanic tuffs, and marls (mainly in basal part) very rich in foraminifera, described as the ‘Globigerina Marls’, containing commonly *Praeorbulina* spp., *Orbulina suturalis*, *Globigerinoides triloba*, *G. sacculifer*, *Globorotalia bykovae*, *G. transsylvanica*, *Paragloborotalia mayeri*, *Globigerina bulloides* etc. (Crihan, unpublished data), (Lower-Middle Badenian);

(ii) **The Evaporitic Formation**, which is mainly made by salt breccias, gypsum as beds or lenses, salt accumulation and very thin silty clays beds (Middle Badenian, i.e. Wieliczian in age);

(iii) **The Radiolarian Shale Formation** that is composed by argillaceous shales, rich in radiolarians, frequently containing taxa such as: *Coenosphaera*, *Dictyocoryne*, *Halicapsa*, *Rhopalodictyum*, *Sethocapsa* and *Spongodiscus*, as well as sands and sandstones;

(iv) **The Spirialis Marl Formation**, developed in a predominant pelitic facies.

DAY ONE

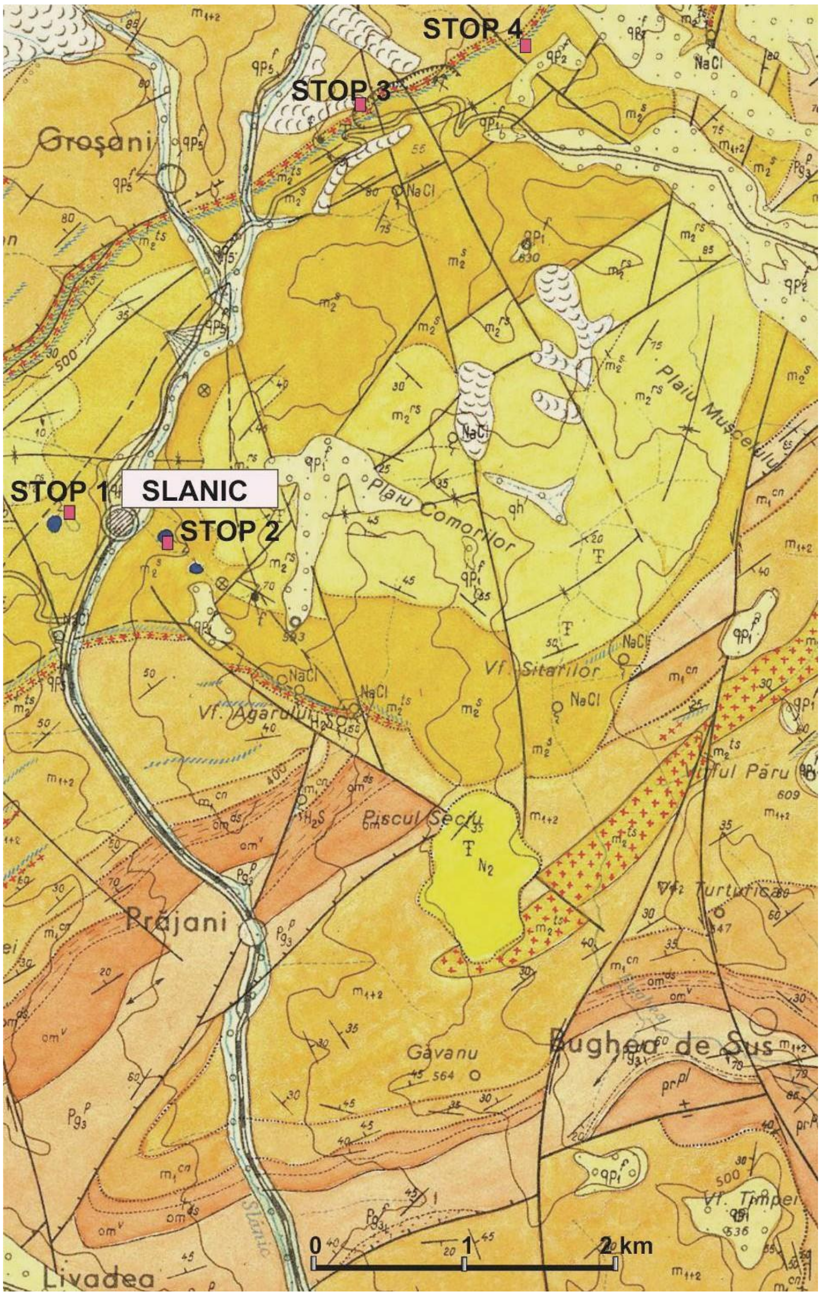


Fig. 8b. Geological map of Slănic Prahova area and the field trip route for the 1st day. Copyright @ IGR.

1st STOP
Middle Badenian evaporitic formation in the Salt Mountain

The uncovered Salt Mountain, (Fig. 13), as well as the Bride's Cave and the Baia Baciului Shepherd's Mine), were included in the geological and geomorphological nature reserve since 1954. The main objectives are the Salt Lake and the Salt Mountain, which once housed the Bride's Cave, now partially collapsed due to rain erosion. Legend says that almost 100 years ago, a bride from the neighbours, forced to marry against her will, thrown into space on its top.

The Middle Badenian salt of the Salt Mountain has been exploited since the end of the 18th century until 1852, when it was flooded by water; thus, a saline lake was formed inside. Because of the freshwater infiltrations and landslides, it collapsed; hence, the *Bride's Cave*, with a salinity of 260 g/l and with the initial water depth of 32 m, now is partially collapsed due to rain erosion. The anthropic activity also negatively impacted the area.

DAY ONE

Fig. 9. The Salt Mountain (the Evaporitic Formation, Middle Badenian) at SlănicPrahova. Photo: Marius Stoica.

2nd STOP
Middle Badenian salt mine

Known as the biggest salt mine in Europe, the Slănic Prahova stands today for one of the most important watering and climatic resorts in Romania, situated at about 44 km of Ploieşti town at 400 m altitude.

The Old Salt Mine (Unirea) was transformed in a sanatorium, at 210 meters deep, for the treatment of pulmonary diseases in a saline air microclimate; the possibility of having hot mineral waters baths in bathtubs, cold baths in the lake, hot mud applications. The mineral waters springs (with compounds of calcium, chlorine, sodium, sulphur) and the lakes Baia Baciului (The Shepherd's Mine), Baia Roşie (The Red Mine), Baia Porcilor (The Pigs' Mine), Lacul Verde (The Green Lake), with a high concentration of salt, are used for treating some rheumatic diseases (Bulgăreanu, 1996).

The mine comprises of 14 chambers with trapezoidal roof profiles, having a 10 m width at the ceiling and 32 m at the ground, a height of 54 m and a wall inclination angle of 60 degrees on the trapezoidal roof section, which is 10 metres high. The difference between the ground surface and the base of the mine is of 208 m and it is covered by the elevator in 90 seconds (now the access to the salt mine is made by minibuses). The excavated space occupies a volume of 2.9 million m^3 and it has a floor area of 78,000 m or 7.8 Ha.

A remarkable stability of the environment is to noticed, due to the constant temperature all over the years of 12.5^{o}C, a relative humidity of 60 to 65 % and a germ load of 700 germ/m3. Due to this setting, recently an Ultralow Background Radiation Laboratory was built in the mine (by researchers of University of Bucharest, Faculty of Physics led by Professor Octavian Duliu).

According to the existing documents, the property of Slănic was bought by the sword-bearer Mihai Cantacuzino around 1685. The first exploitation was opened in 1688 on Valea Verde (the Green Valley) and a few years later opened the exploitation from Baia Baciului (The Shepherd's Mine). In 1881, the mine Carol was opened,from which the salt was extracted for 61 years, until 1935, and starting with 1912 the mine Mihai was open. Otherwise, in 1912 the mine Mihai became the first electrically illuminated mine in the country, and the year 1931 brought now *methods of exploitation by using the explosives and the coal-cutting machines. In 1934 they passed forward to a new drift, called Unirea, situated under the mines Mihai and Carol. Then, from 1970 until 1992 they worked at exploitation in the mine Victoria.*

Fig. 10.Interior view of the main gallery in the Slănic-Prahova Salt Mine. Photo: Mihai E. Popa.

The salt excavated in the Slănic Prahova mine is Middle Badenian in age and cover the green tuff of the Slănic Formation. Salt looks like crystal aggregate and as gritty mass in the salt body, one can observe white, grey and blackish salt strata, folded and interbedded. The grey or blackish salt has smaller crystals as compared to the white one. The general aspect of this deposit is a variegated one. The colour change reflects turnovers that took place in the precipitation process, due to the climatic variations and changes in sedimentary input into the sedimentary basin (Har et al., 2006). According to the above-mentioned authors, two different genetic types of minerals are present in the salt deposit from Slănic Prahova:
(i) Authigenic minerals, genetically related to the precipitation processes into the sedimentary basin under evaporitic conditions: halite (which is the most abundant mineral – 95 wt %), anhydrite, gypsum, polyhalite, and dolomite;
(ii) Allogenic minerals resulted due to the sedimentary input in the basin: quartz, feldspars, muscovite, clay minerals etc. The episodic input of the allogenic minerals into the basin is consistent with the presence of dark-color interbedded strata in the salt deposit from Slănic Prahova.

The sedimentary sequence of the salt deposit from Slănic Prahova covers the interval from the last stage of carbonates precipitation to halite, without reaching the episode of K and Mg salt precipitation.

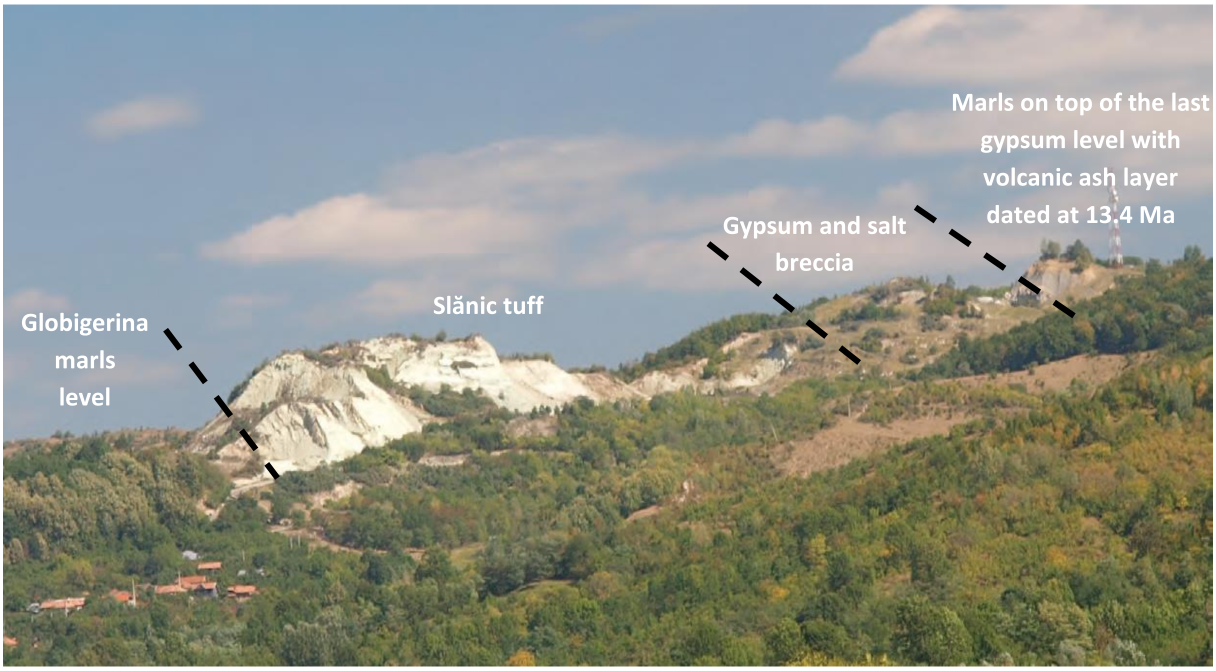


Fig. 11. View of the Piatra Verde hill from the Salt Mine at Slănic-Prahova. Photo: Dan Palcu.

3rd STOP

Middle Badenian tuff and ”Globigerina marls” in the ”Piatra Verde” (The Green Stone) hill

The Slănic Formation s.s. (i.e., firstly described as the Slănic Tuff), is composed of volcanic tuffs, claystones and marlstones; the levels described as the “Globigerina Marls” contain exceptionally rich assemblages of foraminifera, mostly planktonic.

The marly intercalations from the lower part of the unit are characterized by an association made almost entirely of warm water planktonic foraminifera (*Praeorbulina glomerosa, P. circularis, Orbulina suturalis, Globigerinoides triloba, G. sacculifer, Paragloborotalia mayeri, Globorotalia bykovae* etc.). Just bellow a reddish marly intercalation the first appearance of the tropical warm species *Globoturborotalia druryi* was recorded, almost simultaneously with the disappearance of the calcareous nannoplankton species *Sphenolithus heteromorphus*, and the first occurrence of the endemic species *Globorotalia transsylvanica*. The uppermost part of the Slănic Formation, which unfortunately is now covered at Piatra Verde, is also very rich in foraminifera, only that the warm water planktonic forminifera are replaced with a colder water assemblage (*Globigerina bulloides, G. concinna, Globigerinita uvula* etc.), and unlike the lower part of the Slănic Formation which was almost devoid of benthonic foraminifera, from this interval a rich tipical Wielicika type association with *Pseudotriplasia minuta, Uvigerina orbignyana* and other rather deep water species (*Glandulina laevigata, Sphaeroidina bulloides, Melonis pompilioides* etc.) was recorded (Crihan, unpublished data).

In the Piatra Verde (Green Stone) Hill (Fig. 11, 12a), the tuff, exposed in a quarry along the route, is about 80 m in thickness and consists of compact, hard tuffs developed in 0.5 up to 2.0 m thick beds. Its color is mainly green, but also white and bluish, often showing brown alterations.

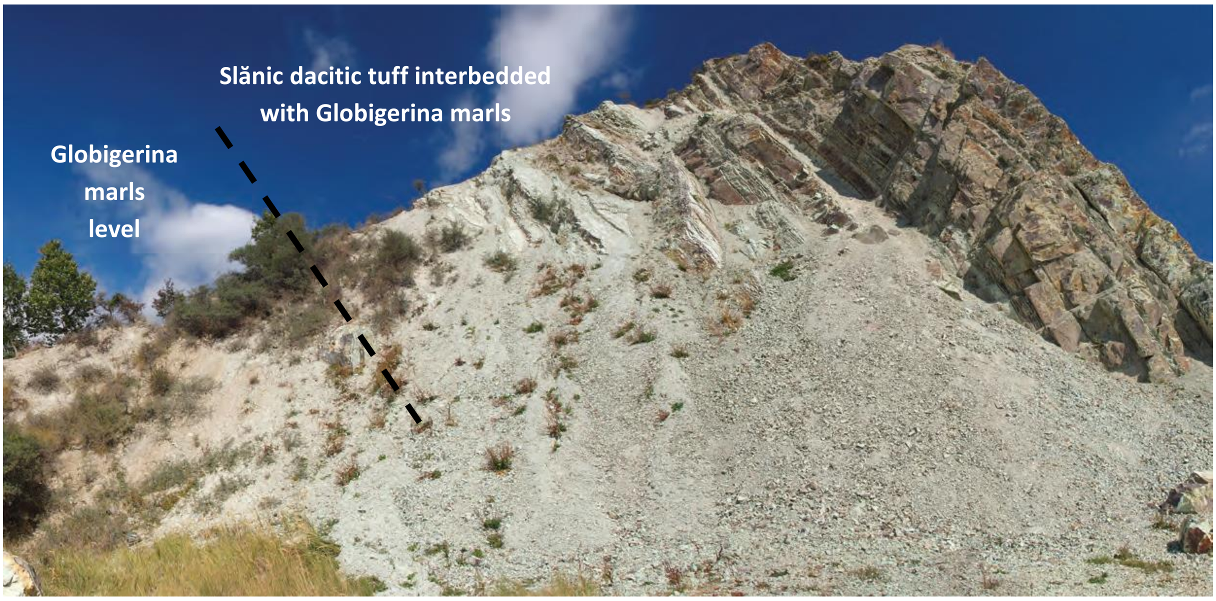


Fig. 12a. Detail of the Piatra Verde site - dacitic ash deposits with Globigerina marls intercalations. Photo: Dan Palcu.

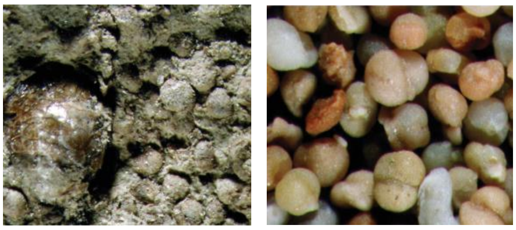


Fig. 12b. Microscope photos of globigerinids (left - unwashed sample; right - washed sample). Photo: Marius Stoica.

4th STOP
The Middle Badenian Evaporitic Formation north of Slănic Prahova

In the Piatra Verde Hill, NE of the Slănic Tuff, the Evaporitic Formation is covered by the marly interval with thin ash layer 40Ar/39Ar dated at 13.45 Ma (De Leeuw et al., 2012). This interval above the gypsum contain a rich Wielician microphauna (foraminifers and ostracods).

The gypsum appears as a 40-50 meters megasequence, divided into two piles of sulphatic lithons, separated from breccia, each lithon having obvious reworking features. The low sulphatic pile shows features of some kind of gravity flow stages with few breaks of algal/clastic rhythmic accumulation. The upper sulphatic pile contains algal/clastic rhythmites, followed by 20 meters of clastic debris (Frunzescu, 1998; 2012).

The marly level above the gypsum provided a rich and diverse microphauna, foraminifers and ostracods. Despite of the bad state of preservation we identified a planktonic association very similar to that recorded from the upper part of the underlying Slănic Tuff, which raises the question of the possible reworking of a part of the fossil material. Among the planktonic species we noticed *Globorotalia transsylvanica* Popescu and *Globoturborotalita druryi* (Akers). The first appearance of *G. druryi* in Paratethys marks the base of the Wielician substage (Popescu 1987; Popescu and Crihan, 2011). *G. transsylvanica* is endemic in the Paratethys as a common Wielician species. Both species were recorded from samples collected bellow and above the dated thin tuff layer.

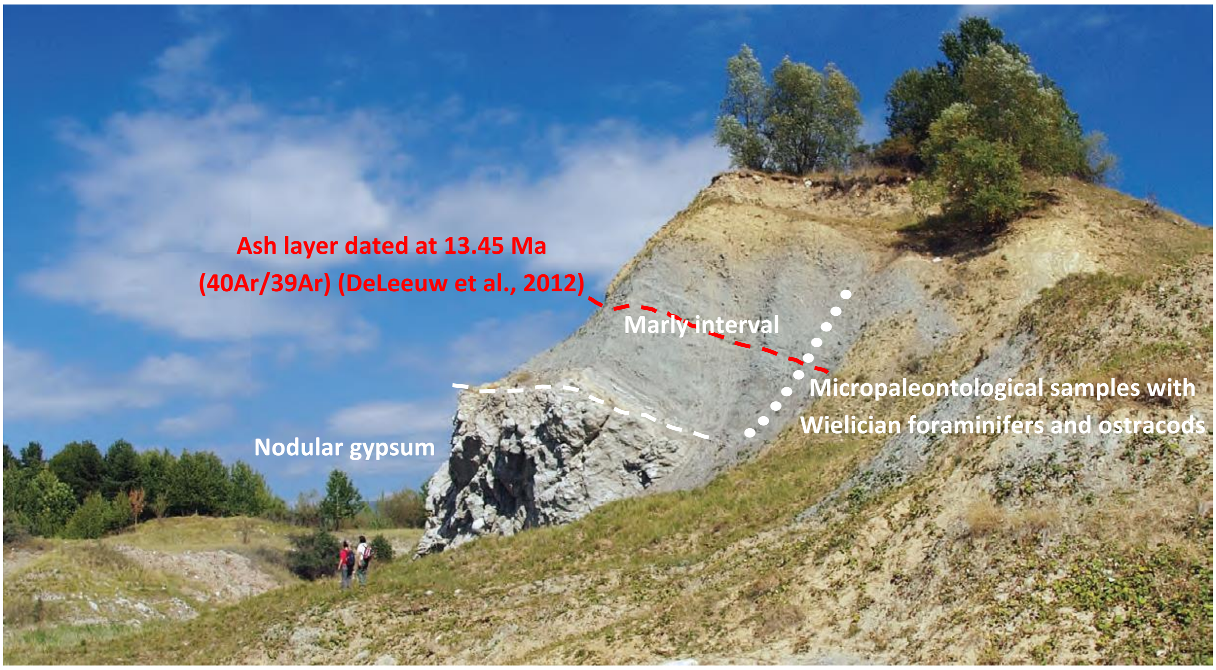


Fig. 13. The Evaporitic Formation followed by the Radiolarian Shale Formation, NW of the Slănic-Prahova town. Photo: Dan Palcu.

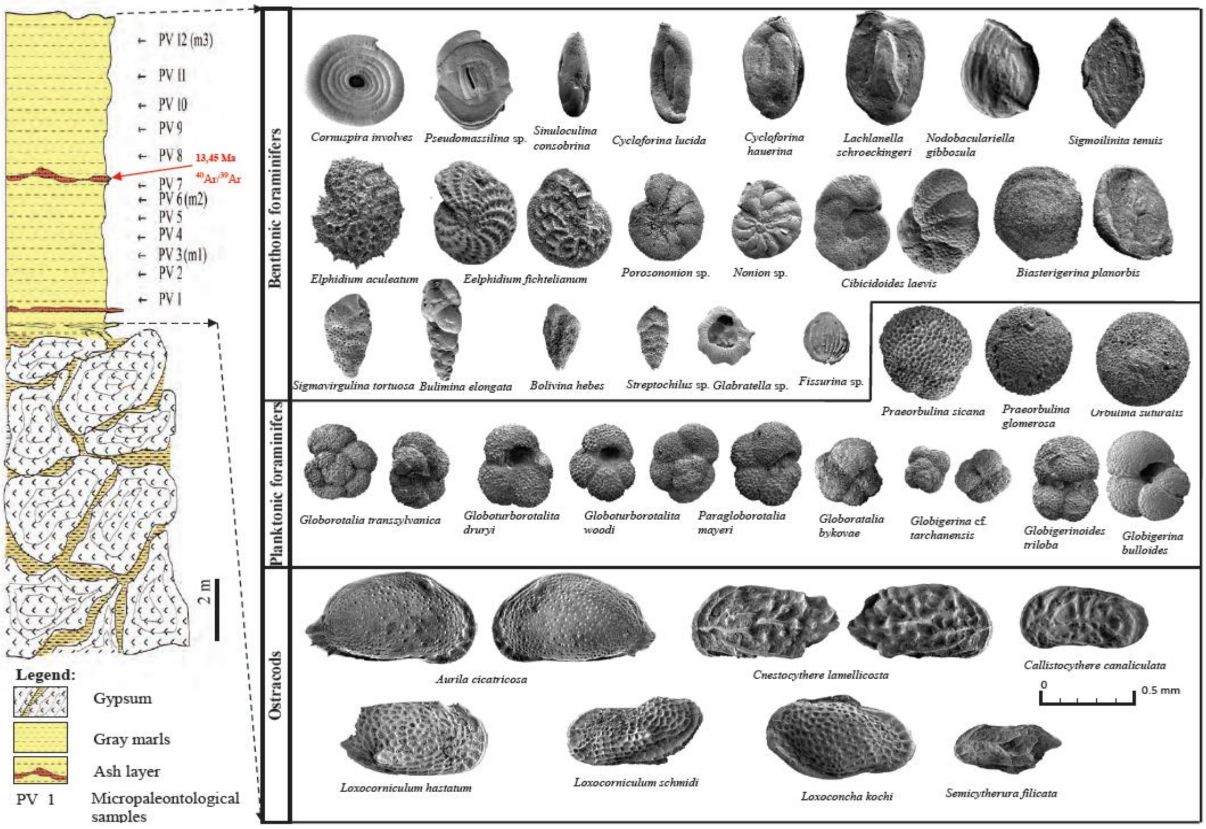


Fig. 14.Wielician microfossils above the gypsum level at Piatra Verde (from De Leeuw et al., 2012)

The benthonic foraminifera are also very rich and diverse. The presence of numerous specimens of the epiphytic species like *Biasterigerina planorbis* (d'Orbigny), *Elphidium* spp., *Glabratella* spp. and *Pararotalia* spp. suggests the inner shelf environment. Frequently, we noticed the *Uvigerina orbignyana* Czjzek, which is a species whose first occurrence is a marker for the lower boundary of the Wielician. Unfortunately, the lack at this stratigraphic level of the index open marine planktonic foraminifera, makes rather difficult the correlation between the Paratethys marine Middle Miocene and the Mediterranean one.

The ostracod fauna is dominated by shallow water species of Middle Badenian age – Wielician. The most common taxa recorded in the gray marls above the gypsum belong to *Cnestocythere lamellicosta* Triebel, *Loxocorniculum schmidi* (Cernajsek), *L. hastatum* (Reuss), *Loxoconcha punctatella* (Reuss), *L. kochi* Méhes, *Callistocythere canaliculata* (Reuss), *C. daedalea* (Reuss), *Aurila cicatricosa (*Reuss), *Phlyctenophora* sp., *Semicytherura* sp., *Heliocythere vejhonensis* (Prochazka), *Tenedocythere sulcatopunctata* (Reuss), *Grinioneis haidingeri* (Reuss), *Pokornyella deformis* (Reuss), *Bairdia subdeltoidea* (Muenster), *Xestoleberis* aff. *Dispar* Muller and *Triebelina boldi* Key.

5th STOP
Lower Miocene gypsum at the Slon Valley

Fig. 15. Folded Lower Miocene gypsum layers on Slon Valley and details of gypsum. Photo: Marius Stoica

In the Slon Valley, gypsum of the Lower Miocene crop out (fig. 15). The gypsum occurs in a faulted syncline. The formation consists in a sequence of alternating layers of nodular gypsum and silto-lutitic rocks. The layers of gypsum vary in thickness from several cm to up to 3 m. The nodules are mostly ellipsoidal in size, only in the case of small size nodules tending towards spherical size. In some cases, it also occurs in columnar habitus. The structofacies of the gypsum layers is dominated by gradual constructional structures: a high frequency of large coalescent nodules (8-12 mm), within a scarce, sometimes absent terrigenous matrix - in the lower part of the layer and rare, small nodules (tenths of mm) floating in an abundant silto-lutitic matrix in the upper part of the layer. This change is seen also in the color of the gypsum that varies upwards from white to gray (Frunzescu, 2004). There are also frequent occurrences of parallel stratification and parallel lamination (rare occurrences of *Balatinogypsum*) as well as occurrences of neptunian dykes, soft or ruditic elements with clay intercalation. From the point of view of the diagenetic evolution, there are occurrences of nodular gypsum, from *penemozaic, mozaic, chicken-wire* and *enterocliths* (Frunzescu, 2004). The gypsum has a high content of siliciclastic allogen components and bioclasts. The nonsulphatic material are represented by black shales with significant content of bituminous material (similar to the disodiles) that tend to be replaced by gray marls towards the top ofthe evaporitic sequence.

6th STOP
Mud Volcanoes at Pâclele

The Berca – Pâcle – Beciu – Arbănași hanging wall anticline is a very young (Quaternary) structural feature developed during the Vallachian deformation phase of the Carpathians. It is oriented NNE to SSW and may be followed for approximately 30 km. The anticline is cross-cut by a number of longitudinal and transversal (tear) faults (Fig. 16a).

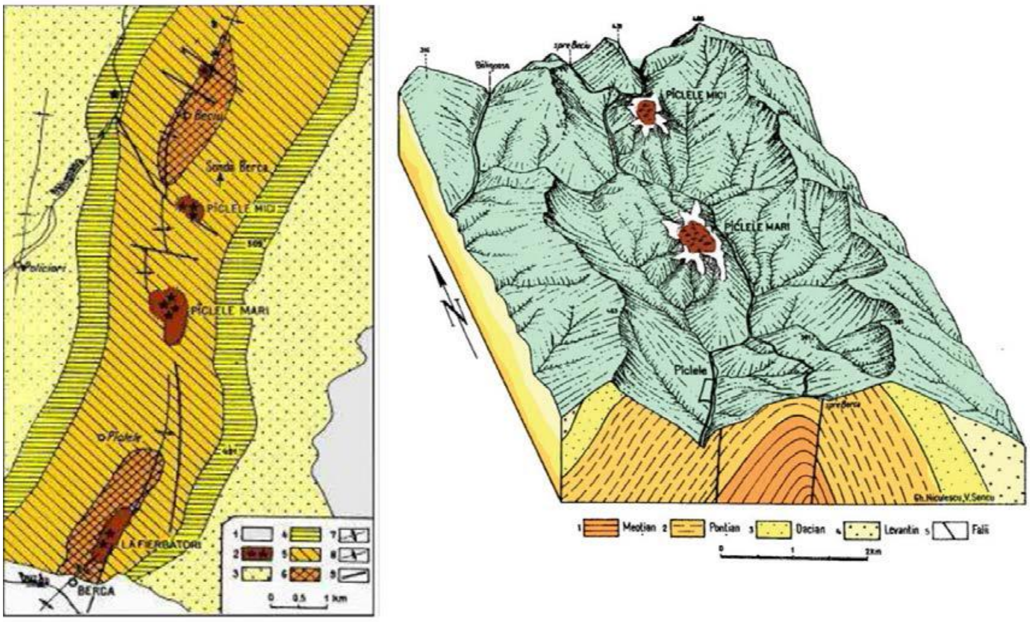


Fig. 16a. Map view and 3D model of the oil fields and mud volcanoes along the Berca – Arbănașianticline. The trap (anticline) age is Quaternary, because the youngest sediments folded are Romanian ("Levantin") in age. The reservoirs are shallow-marine Maeotian sandstones sealed by the transgressive Lower Pontian shale. The charge is interpreted as Oligocene. Note, the mud volcanoes occur in the crest of the anticline (after Dicu, 2005).

DAY ONE

In the axial zone of the fold, Maeotian and Sarmatian sedimentary deposits outcrop. The wells (the deepest over 3 km) encountered a succession of Romanian, Dacian, Pontian, Maeotian and Sarmatian deposits. These are similar in facies to what we observed along the Slanicul de Buzau valley.

The reservoir section consists of more than 27 shallow-marine Maeotian sandstone levels, almost all of them productive. Yet production is complex due to the presence of a number of structural compartments and the sealing properties of the faults. Because of these, not all sand levels are saturated in every structural compartment. The nature of the fluids and their distribution within the alignment are different. The eastern flank is producing oil with gas in all sectors of the structure. In contrast, the western flank is productive only at Pâcle and Beciu.

The complex fault network locally breaches the Lower Pontian top seal. These breaches created pathways for hydrocarbon (especially gas) migration to the surface and development of the Mud Volcanoes. The migrating gas (mostly) and reservoir water collect shale particles along the way and erupt as a mud flow at surface. Successive eruptions end up building volcano-like features. The eruptive mud flows down the cones and generates features similar to lava flows.

Mud eruptions occur in two places, close to Berca Village, at Pâclele Mari and Pâclele Mici. Both areas have been included in the list of the protected areas in Romania and form a geological and botanical reservation of about 30 hectares.

The Pâclele Mici plateau represents a 9.4 ha natural reservation ever since 1924. The object of the protection is the landscape and the presence of halophile plant species – *Nitraria schoberi* and *Obione verrucifera*. At Pâclele Mici, the mud volcanoes are scattered on the plateau. They form groups of 3 to 5 volcanoes, each 2-8 m high with craters of 10-100 cm diameter.

In turn, at Pâclele Mari, the mud volcano craters are typically larger than 1 m and are centrally located on the plateau. The flanks of these cones are widely spread, often with secondary volcanoes. The external part of the plateau, fragmented by ravines and torrents resemble the landscape of badlands.

Fig. 16 b. Mud volcanoes: (a) mud flows similar to volcanic lava flows; (b) barren plateaus, strongly eroded by rainfall and surface water flow; (c) surface flows of oil and mineralized water, rich in sulphates; (d) springs of gas-enriched water. Photo: Dan Palcu.

DAY TWO

Day 2 - Slănicul de Buzău Valley

The second day of the field trip starts from Pleşcoi on Buzău Valley, in the vicinity of the oldest oilfields in Romania (Berca-Arbănași). It will follow upstream the river Slănicul de Buzău, a mildly salty river, that originates in the southern part of the Vrancea Mountains. Following the river, we will pass the southeasternmost hills of the Subcarpathians correspond to anticline and syncline structures of the inner zone of the Foredeep, which are oil-bearing structures (Miocene – Pliocene reservoirs) and Miocene deposits of the Subcarpathian Unit.

We shall visit the following objectives (see the map bellow):

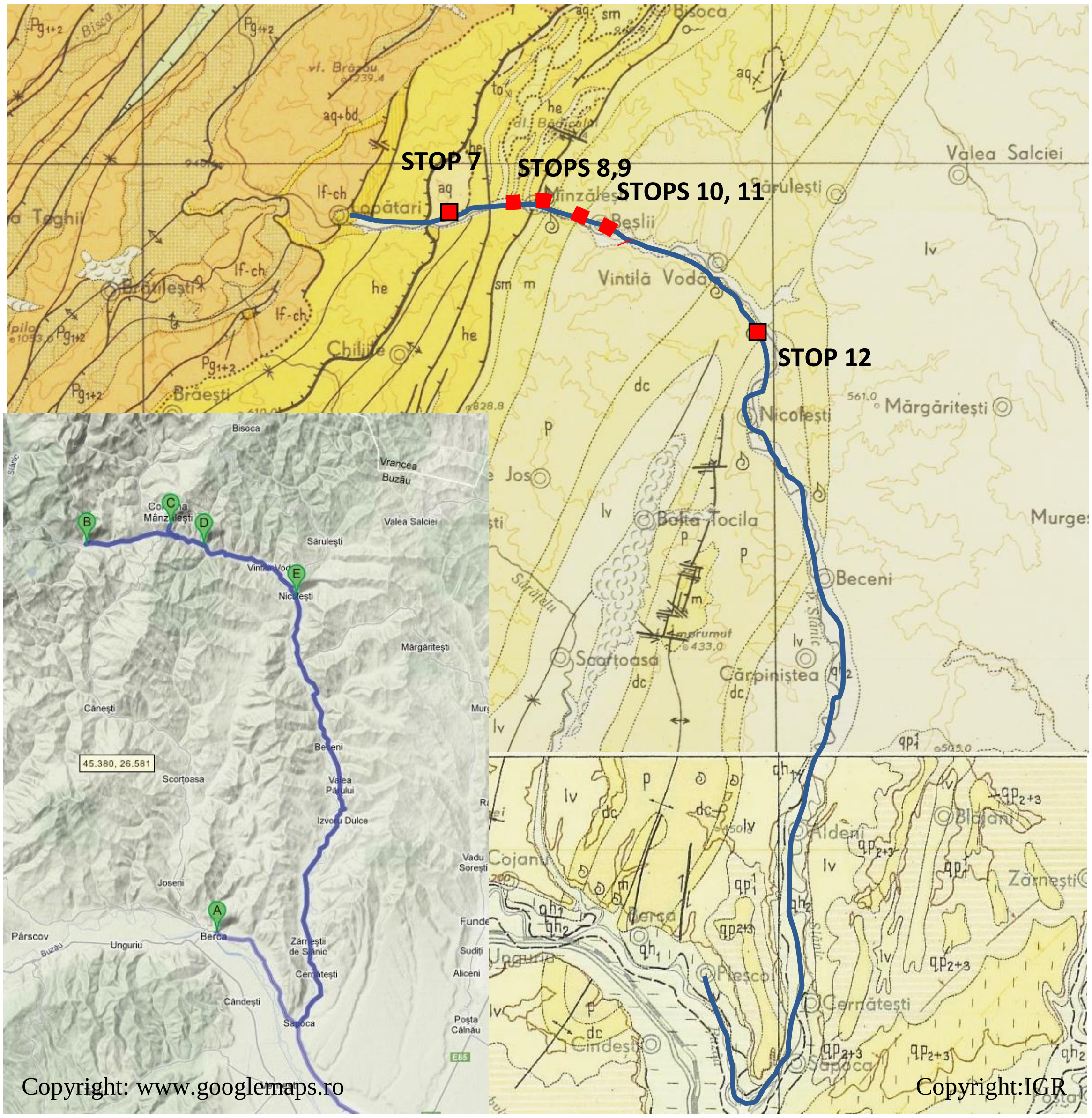
Stop 7.- Lower Miocene Lopătari – Meledic salt diapir

Stop 8,9. - The geological profile along Slănicul de Buzău Valley at Mânzălești (Burdigalian, Badenian and Sarmatian deposits)

Stops 10,11. - Geological profile along Slănic Valley between Beslii and Vintilă Vodă Villages (Maeotian, Pontian, Dacian and Romanian deposits)

Stop 12.- The stratotype of Dacian / Romanian boundary at Niculeşti Village.

Aditional stops in **„Ținutul Buzăului" Geopark**: "*7 Locuri de Poveste*" Museum in Lopătari Village and "*Timpul Omului*" Museum in Mânzălesti Village



DAY TWO

7th STOP

Lower Miocene Lopătari – Meledic salt diapir

Downstream from Lopatari village, on Slănicul de Buzău Valley there is a huge outcrop of a salt diapir. It is actually located near the contact with Tarcău Nappe, within the Subcarpathian Nappe, along Slănicul de Buzău Valley.

Fig. 17. The Săreni cliffs, with recrystallised salt on the unstable hill slopes. Photo: Dan Palcu.

The salt is massive, but in certain points there have been noticed reddish clay and siltic interbeds, thus imprinting a parallel lamination-type structure. At the upper part and on the external flanks of the diapir structure, chaotic deposits are to be found, of the salt breccia type, consisting of a reddish dominantly sandmatrix and green schist elements of Dobrudja type as well as fragments of marly sand beds, belonging to younger formations pierced by salt. In this area, the diapirism is due to both the tectonic causes and the differences in the density. Frequent salty springs can be noticed on the base of slope as well as morphological aspect created by dissolution (small caves, salt "lapiez").

Fig. 18. Sinkholes on the Meledic Plateau leading to some of the world's largest salt caves (left); the freshwater Meledic Lake, laying on clay deposits that in their turn lay above the diapir (right). The diapir is responsible for recent local folding that led to the formation of small lakes. Photo: Dan Palcu.

DAY TWO

8th and 9th STOPS

Geological profile along Slănicul de Buzău Valley at Mânzăleşti

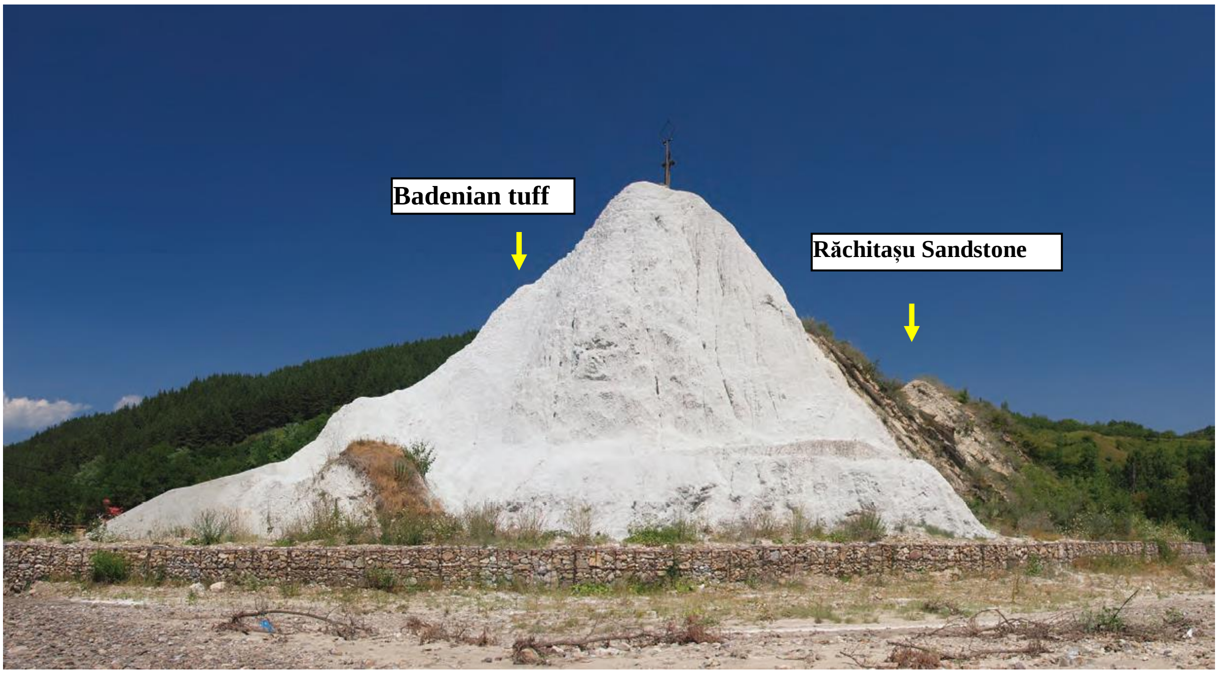


Fig. 19. The outcrop with Badenian Tuff and Răchitașu Sandstone at Mânzălești (Slănic Valley). Photo: Marius Stoica.

The geological profile along Slănicul de Buzău Valley crosses the Subcarpathian Unit and the Carpathians Foredeep (Upper Molasse). It consits from Miocene deposits (Upper Burdigalian, Badenian, Sarmatian and Lower Maeotian). We will see Badenian ash layer, Burdigalian marls with gypsum levels, Sarmatian sandstones rich in *Mactra* (bivalve) shells, reddish continental deposits at Sarmatian / Maeotian boundary.

The scope of this profile is to point out the main characters of Miocene deposits as well as the complicate geological structure of the Subcarpathian Nappe and its tectonical relations with the inner zone of the Foredeep along the Cașin – Bisoca Fault.

In this section the upper Burdigalian and Badenian sequences of the Subcarpathian Nappe crop out into a complicated succession of few narrowed tectonic imbrications.

The Upper Burdigalian is represented by so called "The Gray Formation", a sandy-marly complex containing several gypsum layers and marly intercalations.

The Badenian sequence develops in this sector into an intermediate facies between the Slanic Tuff Facies and Răchitașu Sandstone Facies. It is represented by whitish or greenish dacitic tuffs (equivalent of Slănic Tuff) and interbeds of calcareous matrix sandstones (Răchitașu Sandstone) with quartz, green shists, limestones grains and autigene glauconite. The Badenian age of this sandstone is proved by the Globigerinidae associations identified in marly intercalations. In the lower part or interbedded with the tuff layers can be notice so named "globigerina marls" represented by gray - brownish or greenish marls very rich in planktonic foraminifers: *Praeorbulina transilvanica, P. glomerosa, Candorbulina universa, Globorotalia mayeri, G. bykove, Globigerinoides triloba, G. irregularis* etc.

The profile starts at the bridge to Poiana Vâlcului Village where the Badenian Slănic-type tuff and marls in relation with the Răchitașu sandstone are exposed into a spectacular erosional outcrop with a cross on top (La Grunj). The whole succession from the tufitic globigerina bearing marls, whitish tuff and Răchitașu Sandstone seem to be overturned due the effect of the proximity of major Cașin-Bisoca Fault that marks the overthrust between Subcarpathian Unit and Foredeep.

From this point our geological trip will continue downstream, on the left bank Slănic Valley where the Upper Burdigalian sediments of the "Gray Formation" are exposed. They are represented by interbeds of calcareous, micaceous or gypsiferous sandstones, silts, gray marls with few thin gypsum intercalations or lenses. Frequent, inside this sequence can be seen microfolds, due to the anhydrite hydration. Close to the concrete bridge that cross the Slănic River, a new Badenian sequence with a thicker layer of green tuff and few interbeds of tufitic sandstones, consolidated green silts and marls can be observed in talveg.

Fig. 20. „The Gray Formation"- Burdigalian (left) and massive green tuff and tufitic sandstones – Badenian (right) at Mânzalești Brige on Slănic Valley. Photo: Marius Stoica.

Fifty meters downstream of the bridge, this sequence come into a tectonical contact with Sarmatian deposits along the Cașin - Bisoca Fault. On Slănic Valley Section this fault is marked by a "faults system" and a disturbed zone where the Badenian tufitic sandstones and marlstones are in angular contact with **the Sarmatian** (Upper Bessarabian) calcareous sandstones and silts rich in *Mactra* shells. The mélange zone is marked on landscape.

Fig. 21. Middle Sarmatian (Bessarabian) deposits exposed on Slanicul de Buzau Valley; sandy intercalation with concretions and deformed sandstone lenses that suggest a mass flow type deposit (left); calcareous sandstone block very rich in *Mactra* shells (right). Photos: Marius Stoica.

Downstream of this faulted zone can be seen lots of big blocks of calcareous sandstones very rich in Mactra shells: *Sarmatimactra fabreana*, *S. podolica*, *S. pallasi*. The first Sarmatian deposits in place, crop out approximately 60-70 m downstream of the fault zone and are represented by interbeds of gray-greenish calcareous sandstones separated by gray marls and silts. At some levels, rich fossil intercalations with *Mactra* shells or thin layers with vegetal material can be observed.

DAY TWO

The sandstone beds frequently show sedimentary structures (oblique or cross-laminations on base, parallel lamination or wave-ripples on top). Few sandy levels have a mass flow aspect or presents rounded or lenses- shape concretions.

To the upper part of this profile, sandstone layers are thicker and contain frequent shells of *Sarmatimactra caspia*, *S. balcica*, *S. bulgarica* that prove the presence of Upper Sarmatian (Kersonian).

A particular aspect of this upper sequence is represented by an interval (10-12m) with interbeds of greenish, reddish and blackish silty-clays. These variegated clays represent a marker for the top of Sarmatian in all over the East Charpathian Foredeep. The clays contain a pore fresh water or continental fauna. Formerly, this interval has been assigned to the base of Maeotian, but later has been found few levels with small *Mactra* above that lead to the conclusion that this marker interval must be placed in the Uppermost Sarmatian. Few tens of meter above it, after the last levels with *Mactra* shells, a successions of thick gray sandstones separated by gray clays and silts crop out downstream of Slănic Valley and represents **the Lower Maeotian** sequence.

Fig. 22. Late Sarmatian (Upper Kersonian) sequence with an intercalation of greenish and red clays (marker level) covered by few cycles of sandstones (some of them with wave ripples on top) separated by gray silts and clays. Few levels rich in small *Mactra* shells occur on top of some sandstone. Photo: Marius Stoica.

DAY TWO

10th and 11th STOPS
Geological profile between Beşli and Vintilă Vodă Villages

The scope of this geological profile is to illustrate the transition between Upper Maeotian shallow water detrital deposits to more basinal fine - grained Lower Pontian ones. Along the section can be noticed the base level changes an evolution of sedimentary conditions during Pontian. This time interval start with a transgression at the Upper Meotian / Lower Pontian boundary, followed by more basinal sedimentary settings (HS) during the Lower Pontian. The Middle Pontian represents a regressive moment (LS) when shallow water (littoral, fluvial, lacustrine) sedimentary conditions are dominant. The Upper Pontian sequence starts again with a new transgression and fine-grain sediments of basinal type developed. To the upper part of Late Pontian, can be noticed the reinstallation of more shallow-water sedimentary conditions.

Upper Maeotian deposits are represented by cycles of deltaic and littoral sediments. The gray-yellowish bodies of sandstones (delta fronts) are separated by gray silts and clays. To the top of Maeotian, sandstones show wave ripples on top (littoral). Coarsening-upwards aspects can be notice and few fossils layers rich in mollusks are present in the upper part of the sequence (Fig. 23, 24). Fossils are represented mainly by freshwater bivalves and gastropods of deltaic and littoral type: *Psilunio (Psilunio) subrecurvus, P. (P.) subhoernesi, Unio subatavus, Leptanodonta rumana, Anodonta sp., Viviparus moldavicus, Valvata (Atropidina) turislavica, Theodoxus (Calvertia) stefanescui, Hydrobia dif. spp.. Pyrgula hungarica* etc. The microfauna is dominated by fresh water ostracods mainly species of *Candona*, *Eucypris*, *Pseudocandana*, *Ilyiocypris*. At some levels developed large population of *Cyprideis torosa*.

Fig. 23. Upper Maeotian deposits on Slănicul de Buzău Valley. a, b - cycles of coarsening-upwards sequences; c - littoral deposits with wave ripples on top; d - *Hyriopsis* sp. Photo: Marius Stoica.

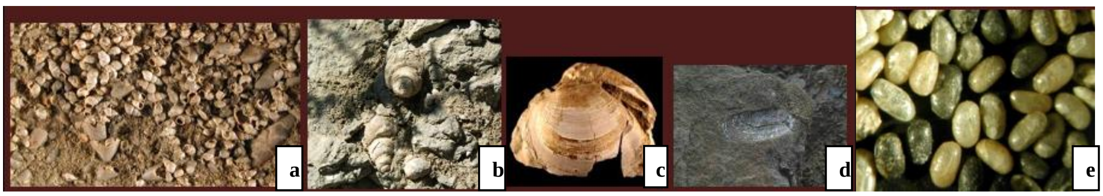


Fig. 24. Upper Maeotian deposits on Slănicul de Buzău Valley. a - Hydrobiid microgastropods; b - *Viviparus moldavicus*; c - *Psilunio* sp; d - *Leptanodonta rumana*; e - ostracod assemblage dominated by *Cyprideis torosa.* Photo: Marius Stoica

DAY TWO

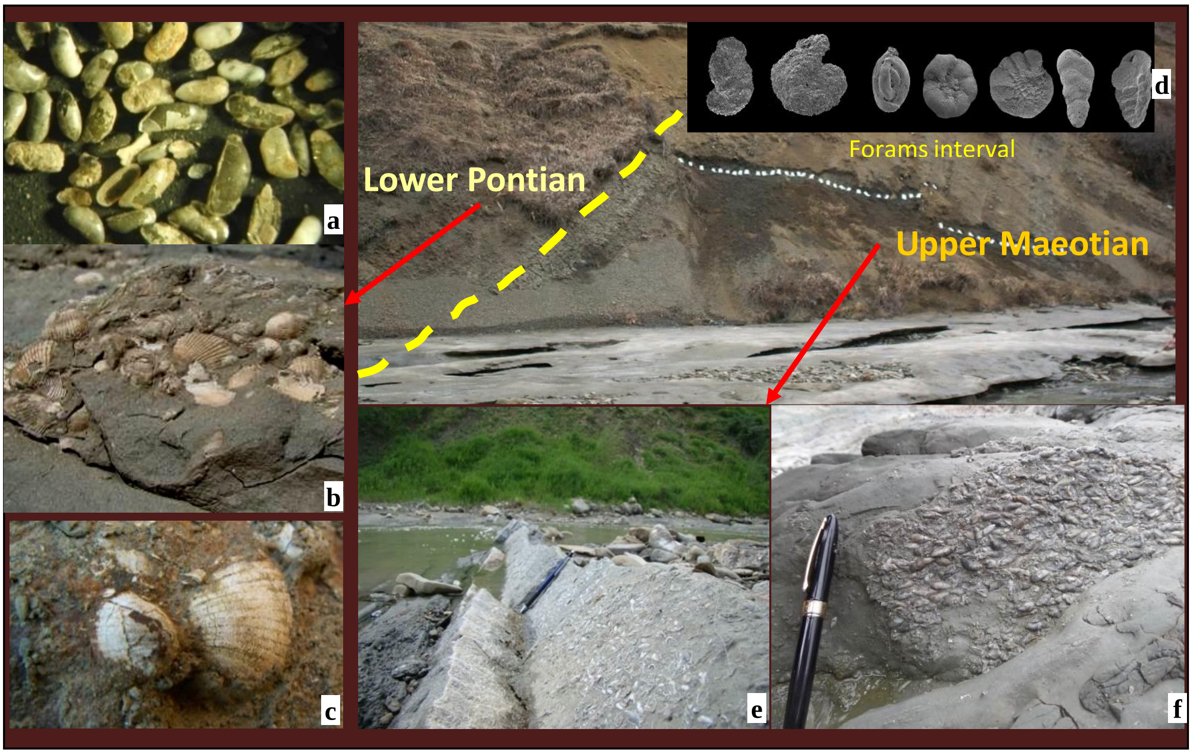


Fig. 25. The Maeotian / Pontian boundary on Slănicul de Buzău Valley. a - pyritized lower Pontian brackish ostracods; b, c - Lower Pontian limnocardiids (*Pseudoprosodacna littoralis, Psudocatylus* sp.; d - foraminifera level (species of A*mmotium, Quinqueloculina, Ammonia, Porosononion, Streptochilus, Bolivina*); e, f - sandstone very rich in *Congeria (Andrusoviconca) amygadaloides novorossica*. Photo: Marius Stoica.

The Maeotian / Pontian boundary. An **important transgressive event** took place at the Maeotian–Pontian boundary. This flooding episode is marked by a sudden lithological change from shallow littoral or deltaic Upper Maeotian sediments to the deeper fine- grain Lower Pontian ones. This event can be recorded for more than 2500Km all over the Eastern Paratethys, starting from Dacian basin (Stoica et al., 2014), to Black Sea (Krijgsman et al., 2010) and further to the Caspian Sea (Van Baak et al.,2016). It coincided with a short-time replacement of the fresher water fauna by a fauna of significantly higher salinity (Fig. 25) proved also by the presence of foraminifera.

The foraminifera assemblage is dominated by the occurrence of benthonic calcareous taxa (species of *Ammonia* and *Porosononion*) as well agglutinated (species of *Ammotium*). The enigmatic planktonic foraminifera genus *Streptochilus* has also been observed in large numbers at the same level. This biserial planktonic foraminifera had previously been assigned to the benthic genus *Bolivina*, but evidence on their apertural morphology, together with accumulation rate data and isotopic composition shows that they lived as plankton, and should be assigned to the planktic genus *Streptochilus* (Smart and Thomas, 2006, 2007). The transitional interval is further characterized by shell accumulations with the bivalve *Congeria (Andrusoviconca) amygadaloides novorossica* that, together with foraminifera level, can be used as a high resolution biostratigraphic marker for the Maeotian – Pontian boundary, dated magnetostratigraphicaly at 6.1 Ma (Krijgsman et al., 2010). The association of *C. (A) amiygdaloides novorossica*, microgastropods and unionids mollusk fauna is abruptly replaced by an association with limnocardiids, marking the base of the Pontian according to its original definition. The microfauna dominated by foraminifera is replaced as well by brackish ostracods. Most of Pontian mollusk and ostracod species migrated from the endemic Pannon Lake as a consequences of base level rise during the flooding event that lead to the reconnection of Dacian Basin with Pannonian Basin. The base of Pontian starts with a short period of anoxic conditions, proved by abundance of sedimentary pyrite.

DAY TWO

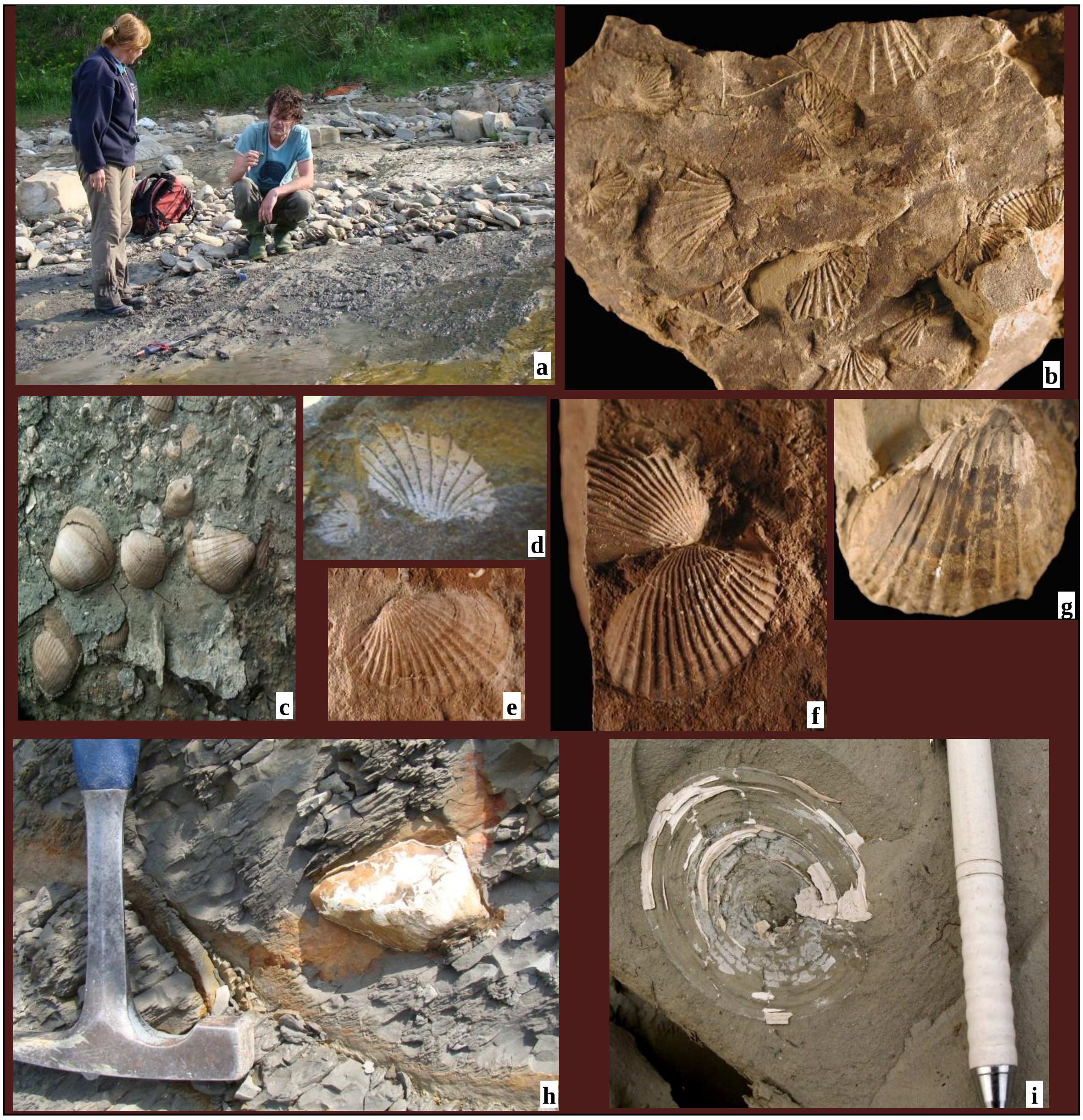


Fig. 26. Lower Pontian pelitic sediments and mollusk fauna from Slănicul de Buzău Valley at Besli. a - Lower Pontian marls; b, d - marls with *Paradacna abichi*; c - *Pseudoprosodacna littoralis littoralis*; e, f - *Pseudocatillus* sp.; g - *Limnocardium (Tauricardium)* sp.; h - *Congeria rhomboidea*; i - *Valenciennius* sp. Photo: Marius Stoica.

The Lower Pontian (Odessian). As a consequence of the Maeotian–Pontian transgression, the Lower Pontian starts with fine pelitic successions, deposited in deeper waters (~ 100 – 150 m). The littoral and fluvial facies from the Upper Maeotian are replaced by more distal ones represented by gray marls with frequent intercalations of ferruginous silts.

An important rejuvenation of the ostracod fauna is observed in the Lower Pontian, resulting in colonization by a large number of species (Fig. 28): *Caspiocypris alta*, *C. pontica*, *Camptocypria ossoinaensis*. *Zalanyiella venusta*, *Hastacandona hysterica*, *H. lotzyi*, *Pontoniella acuminata*, *P. quadrata*, *P. striata*, *Fabaeformiscandona* sp. *Typhlocyprella ankae*, *Cypria tocorjescui*, *Cypria* sp., *Bakunella dorsoarcuata*, *Cytherissa* sp., *Cyprideis pannonica*, *Tyrrhenocythere pannonicum*, *Amnicythere cymbula*, *A.costata*, *A. andrusovi*, *Lepocythere blanda*. The presence of ostracods with eye tubercles indicates the need of the photic zone for their development, in agreement with the presence of green charophyta algae in the same samples. At the base of the Lower Pontian there is a level with pyrite filled ostracods, which is similarly observed in the Taman Peninsula of Russia (Krijgsman et al., 2010) as well in the Caspian Basin (van Baak et al.2016), pointing to large scale disoxic conditions throughout the Eastern Paratethys.

The Upper Maeotian fresh water mollusc fauna is replaced by a brackish one, manly of Pannonian type (Fig. 26): *Paradacna abichi*, *Pseudoprosodacna littoralis littoralis*, *Prosodacna sturi*, *Didacna subcarinata*, *Limnocardium (Tauricardium) subsquamulosum*, *Monodacna (Pseudocatillus) pseudocatillus*, *Congeria rhomboidea*, *Valenciennius* sp. These faunal assemblages indicate that, immediately after the short marine influx at the Maeotian / Pontian boundary, the salinity of the Dacian Basin waters decreased again because of the high influx of continental waters and no/or weak connection with open sea. The Lower Pontian paleoenvironment was generally a brackish large lake/sea with salinities of 7–8‰.

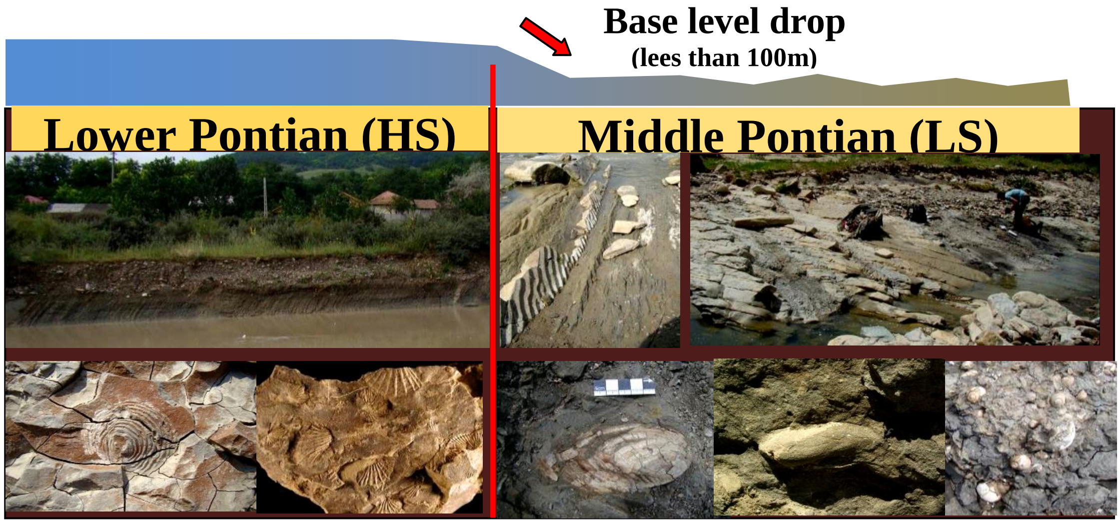


Fig. 27. Lower / Middle Pontian boundary on Slănicul de Buzău Valley, Besli Village; The transition from dominant fine grain basinal deposits (HS) to more proximal, littoral and fluvial ones (LS). The fauna changed from deeper water brackish limnocardiids and gastropods (*Paradacna abichi, Valenciennius* sp.) to fresh water lacustrine-fluvial unionids bivalve (Hyriposis, Unio spp.) and gastropods (*Viviparus, Melanopsis, Bulimus, Lithoglyphus* spp.). Photo: Marius Stoica.

The Middle Pontian (Portaferrian). The base level dropped again in the Middle Pontian and the dominantly basinal pelitic sequence of the Lower Pontian is replaced by a more proximal ones developed in littoral and fluvial-deltaic environments (Figs. 27, 29). The Middle Pontian sediments are represented especially by littoral sandstones with wave-ripples on top, silts and clay formed into flood plain areas, thin coal layers (lignite), lacustrine clays with freshwater mollusks. To the top of this interval, big sandy bodies with erosional futures on sole suggest an important development of transport channels. The mollusk fauna is represented by fresh water lacustrine and fluvial taxa: unioniids – *Unio (Rumanunio) rumanus*, *Hyriopsis* sp., dreiseniids - *Dreissena polymorpha* and gastropods, species of *Lithoglyphus*, *Bulimus*, *Melanopsis*, *Viviparus*, *Planorbis*. Few levels contain abundant *Pseudoprosodacna littorallis* (Cerastoderma) shells, proving the vicinity with the lake shoreline. The ostracod fauna is rather scarce if compared with the Lower Pontian one. The Middle Pontian species are represented by: *Amplocypris dorsobrevis* (a species with robust shell capable of living in littoral environment where sands are deposited in hydrodynamically active regimes), *Candoniella* sp., *Zonocypris membranae* (species able to quickly colonize temporary, short-living lakes), *Cyprideis* ex. gr. *torosa* (littoral species), *Tyrrhenocythere motasi* (a species with robust shell capable of living in sandy – silty environments).

DAY TWO

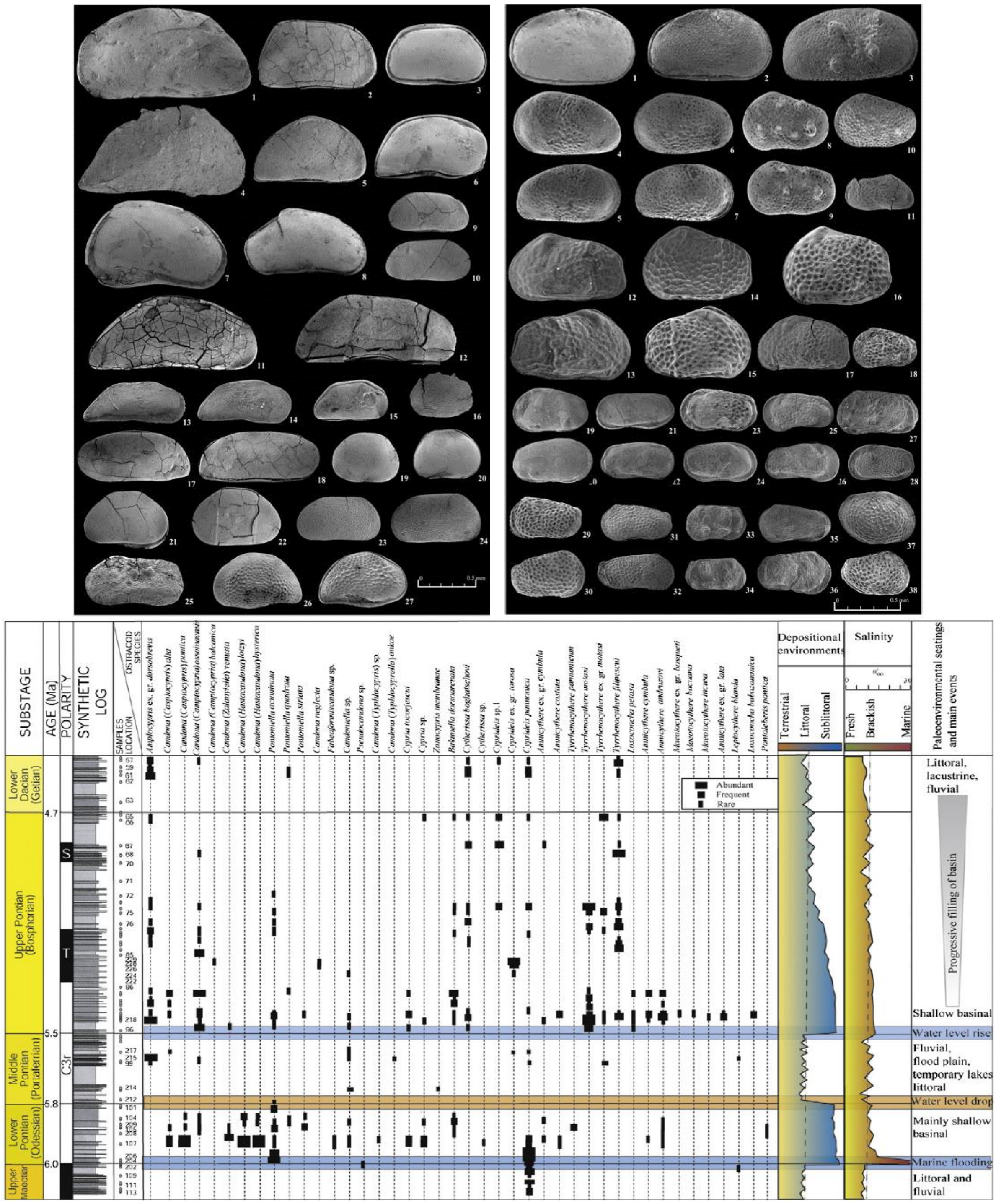


Fig. 28. Pontian ostracods and their distribution in Eastern Carpathian Foredeep (Dacian Basin) (from Stoica et al., 2013).

The faunal assemblages indicate fresh water environments (0–4‰) and a water level drop (~ 100 m) relative to the Lower Pontian one. The origin of this lowering of water level during Middle Pontian is still under debates. The relation of this event with the peak of Messinian Salinity Crisses (MSC) is not excluded, but for the moment there are some inadvertences concerning the time control. The climatic influence is not excluded too.

Fig. 29. Sedimentological and paleontological aspects of Middle Pontian deposits, Slănicul de Buzău Valley at Besli. a - fluvial-lacustrine deposits cropping-out along Slănicul de Buzău Valley; b, c - wave- ripples on top of sandy littoral sediments; d - transport channel with erosional futures on the sole; e - flood plain deposits with thin coal (lignite) intercalation; f - *Hyriopsis* sp.; g - *Unio rumanus*; h- *Viviparus* sp.; i, j - *Pseudoprosodacna littoralis*; k - lacustrine deposits rich in fresh water gastropods (species of *Bulimus, Lithoglyphus* and *Melanopsis*); l - pyritized fossil roots. Photo: Marius Stoica.

The Middle Pontian (Portaferrian) / Upper Pontian (Bosphorian) boundary. Slănicul de Buzău Section is one of the best profile to illustrate the transition between predominantly shallow water proximal environments (littoral, fluvial or deltaic) of the Middle Pontian (LS) to the more basinal ones in the first part of Upper Pontian.

DAY TWO

The big sandy bodies of Portaferrian (transport channels, littoral sands) are abruptly replaced by a thick interval of gray marls with very few intercalations of silts and sandstones (Fig. 30). The origin of this new transgression in the Dacian Basin is also questionable. There are not strong evidences yet to corelate this event with the refilling of Mediterranean Sea during the Zanclean transgression, but this scenario is not excluded. However, the Upper Pontian (Boshorian) starts with a new short transgressive moment in Dacian Basin. This is very well illustrated in facies distribution as well in the mollusk and ostracod fauna. The fresh water mollusk fauna form Middle Pontian is replaces by deeper brackish limnocardiids and gastropod fauna again in Upper Pontain. Ostracods assemblage reacted in the similar way and in Upper Pontian became more diverse and dominated by brackish taxa.

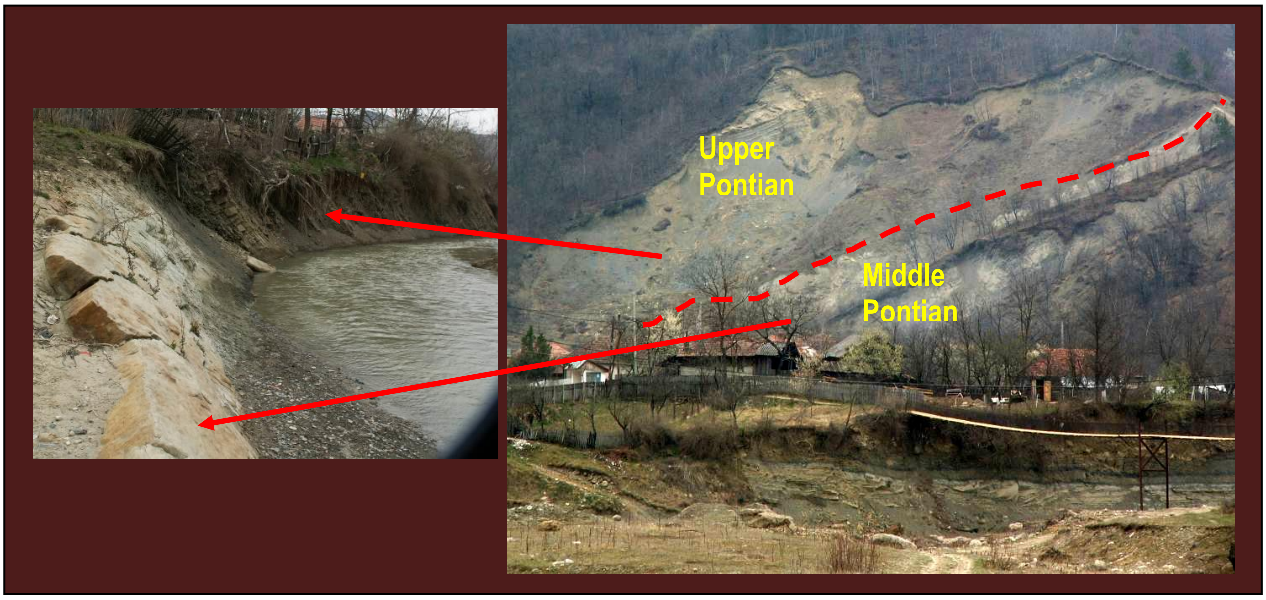


Fig. 30. The Middle Pontian/Upper Pontian boundary on Slănicul de Buzău Valley. Can be noticed the transition from dominantly coarse fluvial sediments to fine-grain basinal ones. Photo: Marius Stoica.

Following this new flooding event observed in the basal part, the Upper Pontian (Bosphorian) sequence (close to the boundary with Dacian) developed again in to shallow water and continental environments. These sedimentary conditions (littoral, fluvial, deltaic, lacustrine) will be the dominant futures in the Dacian and Romanian as a consequence of the progressive filled- up with sediments of the Dacian Basin.

Fig. 31. Upper Pontian deposits at the boundary with Dacian on Slănicul de Buzău Valley. Photo: Marius Stoica.

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12th STOP

The stratotype of Dacian / Romanian boundary, Upper Dacian rich fossiliferous cycles of reddish sandstones

Along Slănicul de Buzău Valley, close to Niculeşti Village a profile on both sides of the river exposed Ramanian (3.8-1,8 Ma) and Dacian (4.9-3.8Ma) sediments. The succession is dominated by interbeds of clays, silts, sands with frequent coaly intercalations (lignite).

The Dacian sediments presents several cycles of ferruginous sandstones very rich in mollusks separated by pelitic intervals. The mollusk fauna from the top part of Dacian sediments is dominated by brackish water bivalves (Limnocardiids) and gastropods: *Prosodacna (Psilodon) haueri haueri*, *P. (P.) neumayri neumyri*. *Stylodacna heberti*, *Chartoconcha* sp., *Zamphiridacna zamphiri*, *Viviparus rumanus*.

The brackish Dacian fauna is replaced by the Romanian fresh water fauna dominated by Unionid bivalves: *Hyriposis* sp., *Jazkoa sturdzae*, *Psilunio (Psilunio) slanicensis* and gastropods: *Viviparus bifarcinatus* and *Melanopsis* spp. The only one limnocardiid bivalve that pas the boundary is *Prosodacnomya sturi*. The lignite intercalations are more frequent in the base of Romanian deposits and an ash layer at the base of Romanian can be notice.

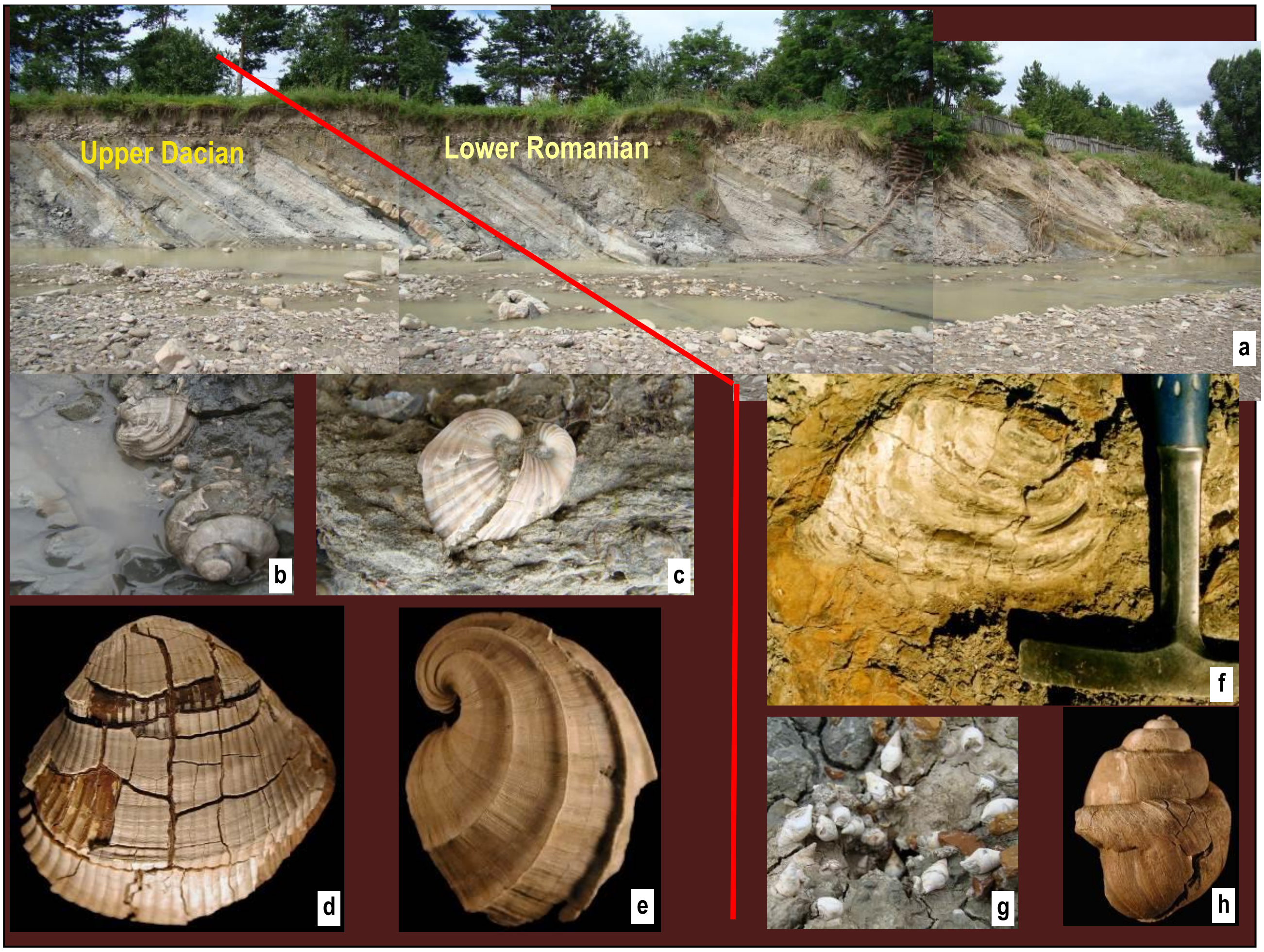

Fig. 32. a - The Dacian/ Romanian boundary and the main mollusk fauna on Slănicul de Buzău Valley (Niculeşti Village); b, c - level rich in *Prosodacna (Psilodon) haueri haueri* and *Viviparus rumanus*; d - *Zamphiridacna zamphiri*; e - *Prosodacna (Psilodon) neumayri neumayri*; f) *Hyriopsis* sp.; g - level rich in *Melanopsis* spp.; h - *Viviparus bifarcinatus*. Photo: Marius Stoica.

Buzau Land Aspiring UNESCO Global Geopark

UNESCO’s General Conference approved, on 17 November 2015, the creation of the International Geoscience and Geoparks Program. UNESCO Global Geoparks are territories well defined from natural, cultural, and administrative point of view, with clear borders, management structure and partnerships able to support their development. A Global Geopark aims to manage geologic heritage, natural and cultural heritage in a holistic concept of protection, education and sustainable development (UNESCO, 2017). The concept as we know today is the result of continuous efforts of dedicated specialists and of innovation and cooperation of different teams and territories across the world. Key elements of this new concept are: 1) innovative approaches in using local geological heritage as one of the main resource for socio-economic development; 2) practical use in geotourism, education and public awareness of local geodiversity; 3) integrated approach and better understanding of the close connection between natural environment and socio-economic needs for sustainable development plans; 4) geoparks are part of the geoconservation, a new branch of applied geoscience; 5) development of a strong international network of Global Geoparks able to foster the process, to assure quality standards and a continuous know how transfer and innovation.

Buzău Land Aspiring Geopark territory is covering about 1036 km2 and is located in the fold and thrust belt of the Carpathians, covering what is known as the Tarcău and Subcarpathian tectonic nappes and the folded foredeep (Bădescu 2005). The area is a highly geodynamic active zone and generates peculiar geologic processes like mud volcanoes, gas seepage (which sometimes combusts and gives rise to eternal flames) or oil and mineralized springs, amber occurrences, salt mountains (diapirs) with salt caves, sandstone concretions, fossils, volcaniclastic deposits, and others. A complete stratigraphic sequence of 40 million years in the Earth history is well preserved and exposed.

Buzău Land includes the territories of 18 communes from the highlands of Buzău County, Romania (Fig. 33). The travellers can get there by using the county and communal roads that follow the course of three rivers: Sibiciul, Bălăneasa and Slănicul de Buzău. There are two main gateways to the Geopark: the gateway through Berca to the Mud Volcanoes, Salt and Living Fire and the gateway through Colti to the land of Mystery, Amber and Rock-hewn Settlements.

Buzău Land Aspiring Geopark has been developed as a grass roots project initiated by University of Bucharest and Buzau County Council in 2006. Local administrations, local and national institutions and associations were continuous involved and sustained the project development. The geopark aims to protect the local heritage, to reinforce the potential for the development of the region and to strengthen local identity (Andrasanu, 2010). The Geopark provides a framework for conservation and promotion of geologic assets and the development of a less conventional tourist destination, with focus on the promotion of geo and bio-diversity and cultural heritage (Popa et al, 2016, Iuga, 2016). For researchers, teachers and students being involved in geopark development is an exercise of sustainable approach, it takes time, a lot of skills and opportunities to learn, discover and share.

A key point in supporting the geopark development is GeoSust implemented between 2014 and 2017. GeoSust is an interdisciplinary applied research project which was bringing together specialists from the fields of earth, human and social sciences. The main outcomes and outputs have been acquired are related to development of natural hazard and risk maps for environmental management and risk assessment via a GIS platform, development of tools for physical planning based on a centralized inventory of sites relevant for geoconservation, improvement of knowledge of how the natural environment has inspired the local human imaginary and customs over

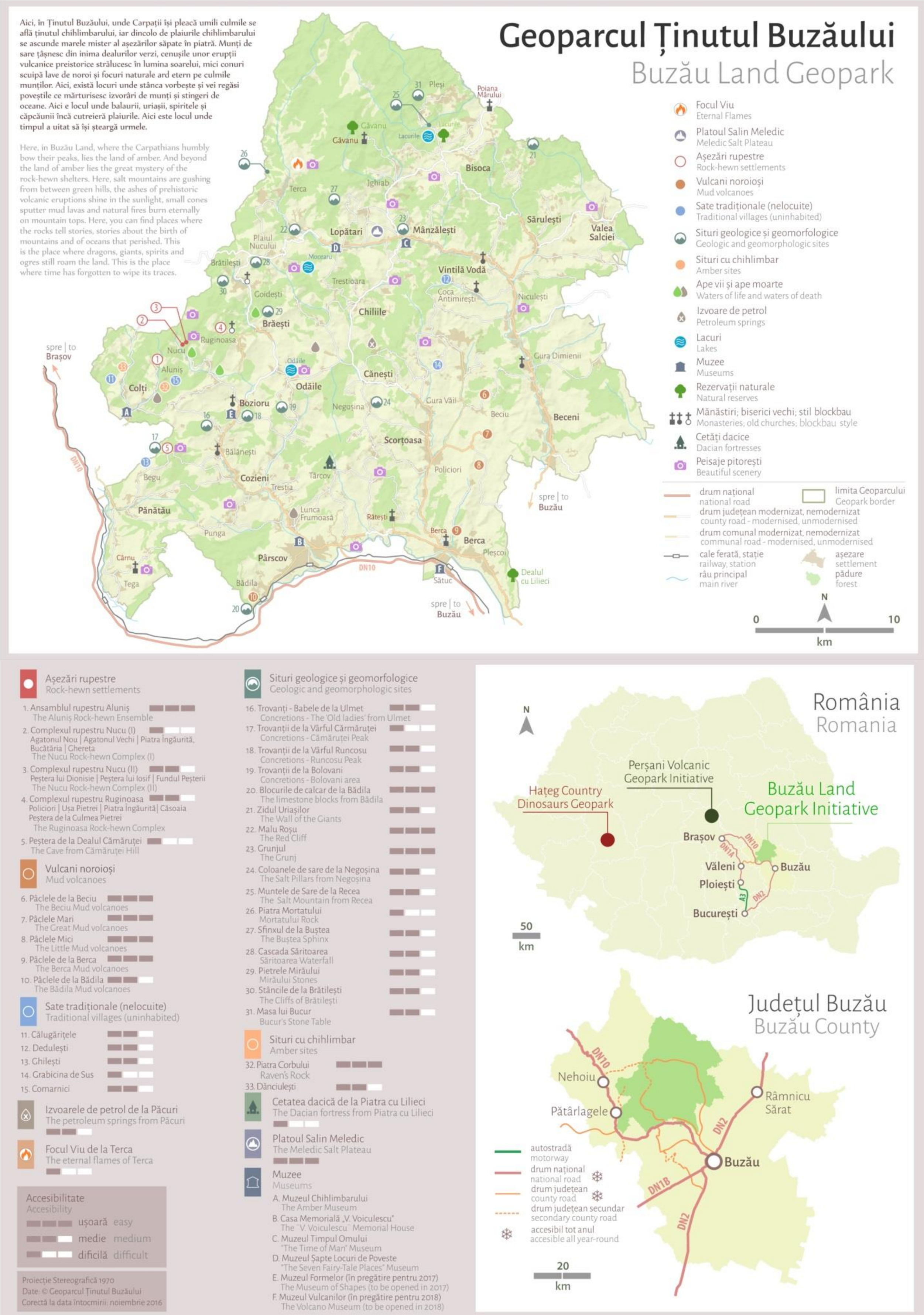

Fig. 33. Buzău Land Aspiring Geopark territory

time, based on an intangible heritage inventory. The project created a good framework to develop strategies and tools for geo-education, public awareness and economic development and to set up the Geopark Management Plan Builded around the geologic, natural and cultural heritage of the area, the geopark reveals the complex connection created over millennia of continuous interaction between human communities and the space they inhabited. Intangible heritage generated by several iconic geologic assets like mud volcanoes, salt, oil and gas seepage, amber, strange sand concretions (trovanti), volcanic ash, , a vertical limestone bed called “the giants`wall” is used to set up a visiting infrastructure of trails and visitor center in order to support tourism, education and socio-economic development. As is shown in the Geopark map a network of sites and local museums was developed, among them (http://tinutulbuzaului.org/). During the field trip two local museums will be visited: The Time of Man Museum and 7 Places for 7 Stories Museum.

The Time of Man Museum, located in Minzalesti, along Slanic Valley, is a symbolical place, a personal space that has been created with pieces from the Mînzălești ethnographic collection and with the help and support of the local community. The museum tells the story of both the seen and unseen connections between Man and Earth from the perspective of Time. The main elements of the museum are the Tree of Life, the oven and the manual mill (Popa & Popa, 2015).

The 7 Places for 7 Stories Museum, located upstream on Slănic Valley, in Lopătari village is telling the stories of local intangible heritage generated by iconic geological places and phenomenon of the geopark territory.

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