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CRETACEOUS TECTONICS AND LITHOSTRATIGRAPHY IN THE ROMANIAN CARPATHIAN BEND, PRAHOVA VALLEY

FIELD TRIP GUIDE BOOK

MIHAELA C. MELINTE-DOBRINESCU AND RELU-DUMITRU ROBAN

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GUIDE OF THE PRE-SYMPOSIUM FIELD TRIP 2

CRETACEOUS TECTONICS AND LITHOSTRATIGRAPHY IN THE ROMANIAN CARPATHIAN BEND, PRAHOVA VALLEY

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1. THE ROMANIAN CARPATHIANS

The Romanian Carpathians belong to the Carpathian Mountain system, which extends over more than 1,300 km from the Danube Valley in Austria to the Danube Valley in Southern Romania. To the north, the Romanian Carpathians are linked with the Western Carpathians, stretching to the south into the Balkan chain. The Romanian Carpathian fold and thrust sheets were grouped into several units, based on their deformation age (Săndulescu, 1984). The main tectonic units are: (i) the Transylvanides and the Dacides, mainly deformed during mid Cretaceous and Late Cretaceous times, (ii) the Moldavides, which were mainly trusted during the Late Paleogene and Miocene, and (iii) the Pienides, which underwent the effects of two main tectonic phases, during Late Cretaceous and Early Miocene times (Fig. 1).

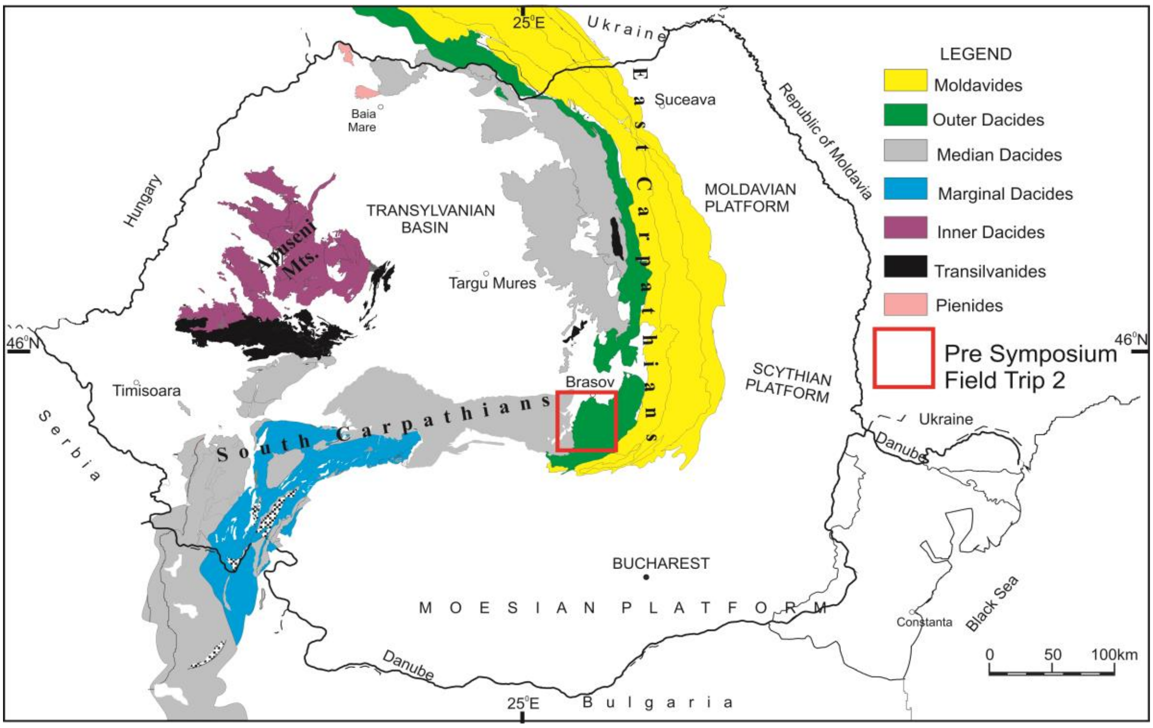

Fig. 1 –Location of the field trip area on the tectonic map of Romania
(modified after Săndulescu, 1984).

The Romanian Carpathians are divided into three branches: the Eastern Carpathians, the Southern Carpathians, and the Apuseni Mountains. The Romanian segment of the Carpathians is composed of a collage of tectonic units that were gradually assembled during the closure of two main oceanic domains, which are kinematically linked to the evolution of the Neotethys and Alpine Tethys (Stampfli and Borel, 2002; Mațenco et al., 2007; Schmid et al., 2020).

2. THE EASTERN CARPATHIANS

The Eastern Carpathians represent a segment (over 600 km long) of the Carpathian Orogen, which develops between the Tisa Spring (towards the north) and the Dâmboviţa Valley (towards the southwest). Inwards (westwards), the Eastern Carpathians are bordered by the Transylvanian Basin and the easternmost part of the Pannonian Basin. Outwards (eastern), the orogen massif is bordered by the Moldavian and Scythian Platforms (eastwards) and by the Moesian Platform (towards the southeast and the south) (Fig. 2).

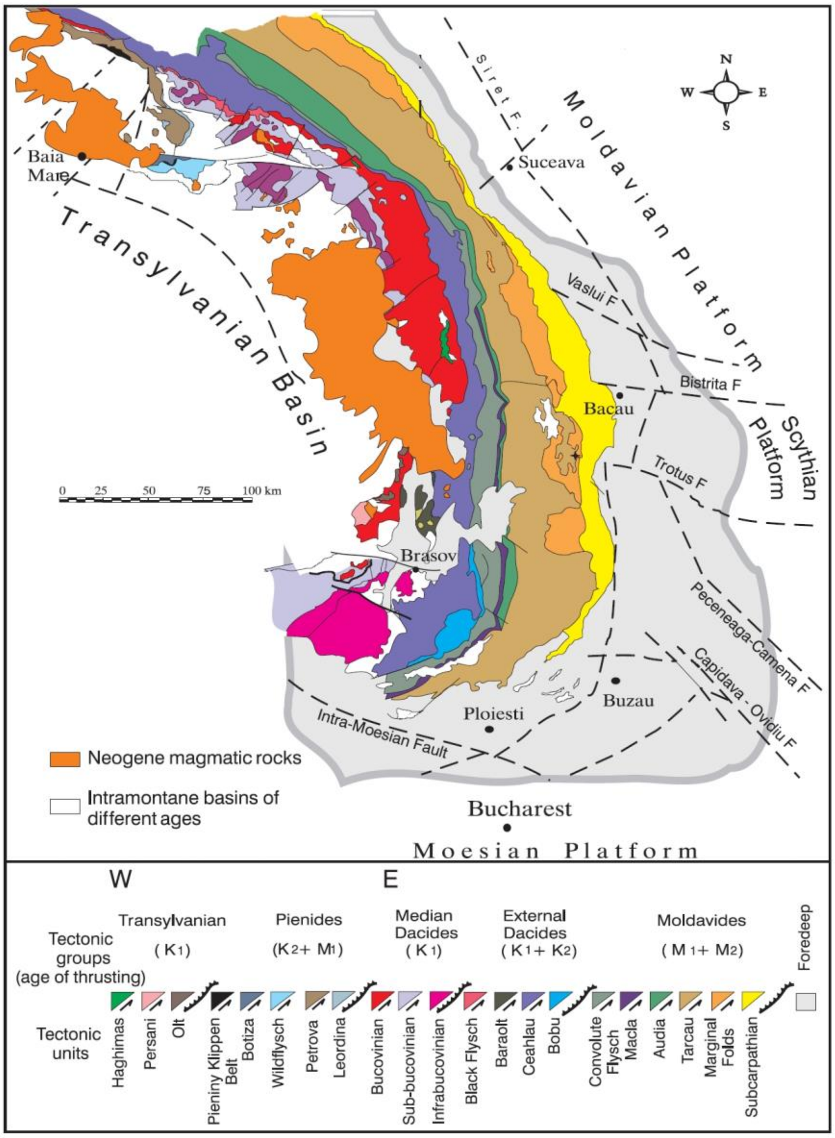

Fig. 2 – Tectonic map of the Eastern Carpathians Belt (after Bădescu, 2005).

The Eastern Carpathian chain represents an arcuate orogen, having a complex structure wherein the flysch nappes modify their trend with 200° from the northernmost area (Poland) down to the south, in the belt zone of Romania. The segment of the Alpine belt comprised between the Tisza Springs in the north and Dâmboviţa Valley in the south represents the Romanian Eastern Carpathians. This orogen continues with the Eastern Ukraine Carpathians to the north and the Southern Carpathians to the south.

This Eastern Carpathian consists of thin-skinned and thick-skinned nappes. The thrusting took place in several steps within the Cretaceous-Miocene interval (Săndulescu, 1984; Csontos and Vörös, 2004; Bădescu, 2005).

The most widespread tectonic unit of the Outer Dacides (thin-skinned nappe) is the Ceahlău Nappe (Fig. 2), which encloses several subunits (Săndulescu, 1984; 1994). In the central and southern parts of the Eastern Carpathians, several tectonic subunits such as Bratocea, Comarnic, Secăria, Ciuc and Bodoc were delimited (Ştefănescu, 1976; 1995). The Bratocea tectonic subunit, which is the innermost (western) one of the Ceahlău Nappe, largely occurs in the southern Eastern Carpathians, and contains several Cretaceous lithostratigraphic units (Fig. 2), the oldest one being the Sinaia Formation, composed of mix, siliciclastic calcareous turbidites.

This Sinaia Formation (Fig. 3) was divided into three members (Murgeanu et al., 1963; Patrulius, 1969; Patrulius *et al*., 1976): (1) the Lower Member ('Shaly' Member); (2) the Middle Member ('Sandy-Calcareous' Member); (3) the Upper Member ('Lamellaptychus angulicostatus' Member). Towards the base of the Sinaia Formation, red and green shales occurred, usually bearing mafic igneous rocks (the Azuga Formation). The occurrences of concordant lava flow within the Azuga Formation, associated with basic tuffs and jaspers, is evidence of a Late Jurassic syn-sedimentary intra-basinal volcanism (Săndulescu et al., 1980; Ştefănescu and Micu, 1987).

The Piscu cu Brazi Formation (Fig. 3), consisting of sandstones, alternating with shales, follows the Sinaia Formation and occurred only in the inner part of the Bratocea tectonic subunit. In the outer part of Bratocea tectonic subunit, within the stratigraphic interval corresponding to the sedimentation of the Piscu cu Brazi Formation, the facies changes such that three lithostratigraphic entities could be distinguished: Comarnic, Vârful Rădăcinii, and the 'Sandy-Shaly Flysch' unit (Fig. 3). All lithostratigraphic units above-described are siliciclastic turbidites, accumulated during the Tithonian-Aptian interval (Patrulius, 1969; Neagu, 1972; Patrulius et al., 1976; Melinte, 1996; Melinte-Dobrinescu and Jipa, 2007).

From the Albian, a 2000 m-thick pile of conglomerates and sandstones, representing the Bucegi Formation, was deposited. To the west, the unit discordantly overlie the Middle and Upper Jurassic carbonate platform. Towards the east, the Bucegi Formation discordantly overlies the Lower Cretaceous km-thick turbidites.

Previous works indicate a shallow marine and nearshore origin of the Bucegi conglomerates (Patrulius, 1969), which were described as a molasse (Panin et al., 1961), mainly due to its coarse grain-size of the clasts, its stratigraphic position above turbidite formations, and its 'post-tectonic' relationship within the tectonic mobile active belt. Some authors (Stanley and Hall, 1978) considered that the Bucegi unit accumulated in an infraneritic to deep marine environment, suggesting the progradation of coarse material directly onto the slope and base of the slope. Recently, Olariu et al. (2014) assumed that the conglomerates of the Bucegi unit are syn-tectonic deposits accumulated into a shallow to deep-water basin. The Getic (Dacides) metamorphic basement and Mesozoic carbonate rock supplied the coarse clasts to the east and north *via* rivers and subaerial mega-debris flows. The conglomerates were probably systematically reworked by river currents, tides, and waves on the shelf (Jipa et al., 2013; Jipa and Olariu, 2018).

Around the top of the Albian, mainly hemipelagic and pelagic deposits were accumulated at the southern end of the Eastern Carpathians. The grey-green, black, and red marlstones and claystones of the Dumbrăvioara Formation were sedimented during the latest Albian - Coniacian interval (Neagu, 1972, 1990; Ştefănescu and Melinte, 1996; Melinte et al., 2007). The Dumbrăvioara Formation is covered by the white marls of the Plaiu Formation and by the red marls of the Gura Beliei Formation (Fig. 3), which encompasses the Cretaceous-Tertiary boundary and extended up to the Paleogene (Melinte and Jipa, 2005).

3. TECTONICS AND LITHOSTRATIGRAPHY OF THE PRAHOVA VALLEY

The oldest sediments that crop out in the Prahova Valley belong to the Ceahlău Nappe (Outer Dacides), the Sinaia Formation. This formation could be divided into three members, as follows (Fig. 3):

(a) The Lower Member, which is composed of thin calcareous sandstones, shales, and marlstones. This member is interfingering towards the inner (western) part of the nappe with the red and green phyllites of the Azuga Formation. Chert levels and nodules are also interbedded. In the studied area the thickness of this unit is between 50-70 m.

(b) The Middle Member (500 up to 800m in thickness), which is made by typical turbiditic sequences (polymictic calcareous sandstones with sole markings, grey and blackish shales, and white or grey marly limestones). Towards the lower part, cherts are interbedded. The most characteristic feature of this unit is the presence of both graywacke turbidites and calcareous turbidites showing complete Bouma sequences, but also truncated ones with a large development of its upper members (Fig. 4)

(c) The Upper Member (150-200 m in thickness), which is similar in lithology to the Middle Member of the Sinaia Formation, is distinguished by the presence of thinner sandstones and lighter marly limestones. Normally graded conglomerates also occur, mainly constituted of metamorphic schist clasts. The Upper Member of the Sinaia Formation is conformably covered by a pile of 800-1,000 m-thick flysch deposits composed mainly of lithic sandstones, with cross lamination, and dark-grey shales (Piscu cu Brazi

Formation). Towards the east (outer part of the Ceahlău Nappe), the Upper Member of the Sinaia Formation is followed by the Comarnic Formation.

This lithostratigraphic unit, which has a thickness of 150-200 m, contains thin bedded marls in its lower part, associated with coarse-grained conglomerates, mainly composed of limestones and elements of medium-grained metamorphic rocks (Jipa, 1961; 1965). The upper part of the Comarnic Formation is made by calcareous turbidites. The formation contains macrofaunas (mainly ammonites and belemnites) and microfaunas, i.e., orbitolinids (Murgeanu et al., 1963; Patrulius, 1969; Neagu, 1972).

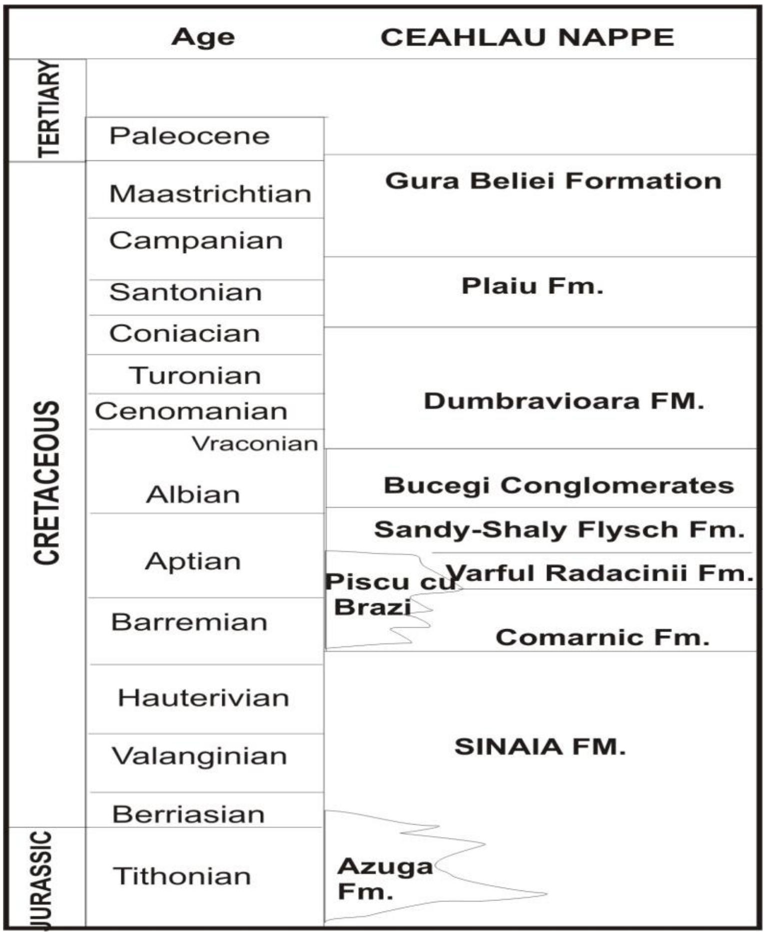

Fig. 3 – Lithostratigraphic units of the Prahova Valley (southern Eastern Carpathians) – compiled after Săndulescu (1984), Ştefănescu (1995), Melinte and Jipa (2005; 2007).

The next unit is the Vârful Rădăcinii Formation (500-700m in thickness), which has as its main lithological feature the deposition of up to 50 m of grey-greenish thin sandstones, grey shales, and argillaceous limestones. These turbidite successions are followed by thick lithic sandstones, which are separated by sandy and silts couples, 10 up to 25cm in thickness. The sole of sandstones frequently shows flute casts and trace fossils. This lithological unit was referred to as the Sandy-Shaly Flysch Formation (Fig. 4). The sandy turbidites are discordantly covered by a pile of conglomerates and coarse sandstones, namely the Bucegi Formation. Frequently breccia levels were deposited at the base of the conglomerates.


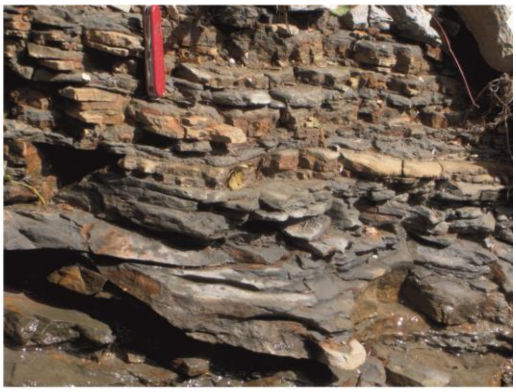

Fig. 4 – The Middle Member of the Sinaia Formation (left); The ‘Sandy-Shaly Flysch’ unit (right).

Several Cretaceous intervals of the sediments cropping out in the Prahova Valley were dated based on calpionellids and foraminifers (Neagu, 1972; Patrulius et al., 1976; Pop, 1997). The detailed assignment of the Lower Cretaceous deposits exposed in the Prahova Valley is based on the calcareous nannofossil biostratigraphy (Melinte, 1996; Melinte and Mutterlose, 2001; Melinte and Jipa, 2007) – Fig. 5

The Cretaceous ends with hemipelagic sedimentation, i.e., the white marlstones of the Plaiu Formation and the red marlstones and claystones of the Gura Beliei that grade up to the Paleocene-Eocene turbiditic deposits of the Şotrile Formation. The latter unit was divided into five members: ‘Violaceous Clays’, ‘Lower Flysch’, ‘Crevedia Marls’, ‘Upper Flysch’ and ‘Buciumeni Marls’ (Ştefãnescu, 1976; 1995).

The presence of small globigerinid microfaunas, within the Lower Member of the Şotrile Formation (in the violaceous shales), indicates a Danian-Thanetian age. Trace fossils, such as *Belorhaphe* and *Paleodictyon gomezi* were discovered in the Eocene deposits of the Şotrile unit cropping out in the Prahova Valley (Brustur, 1993).

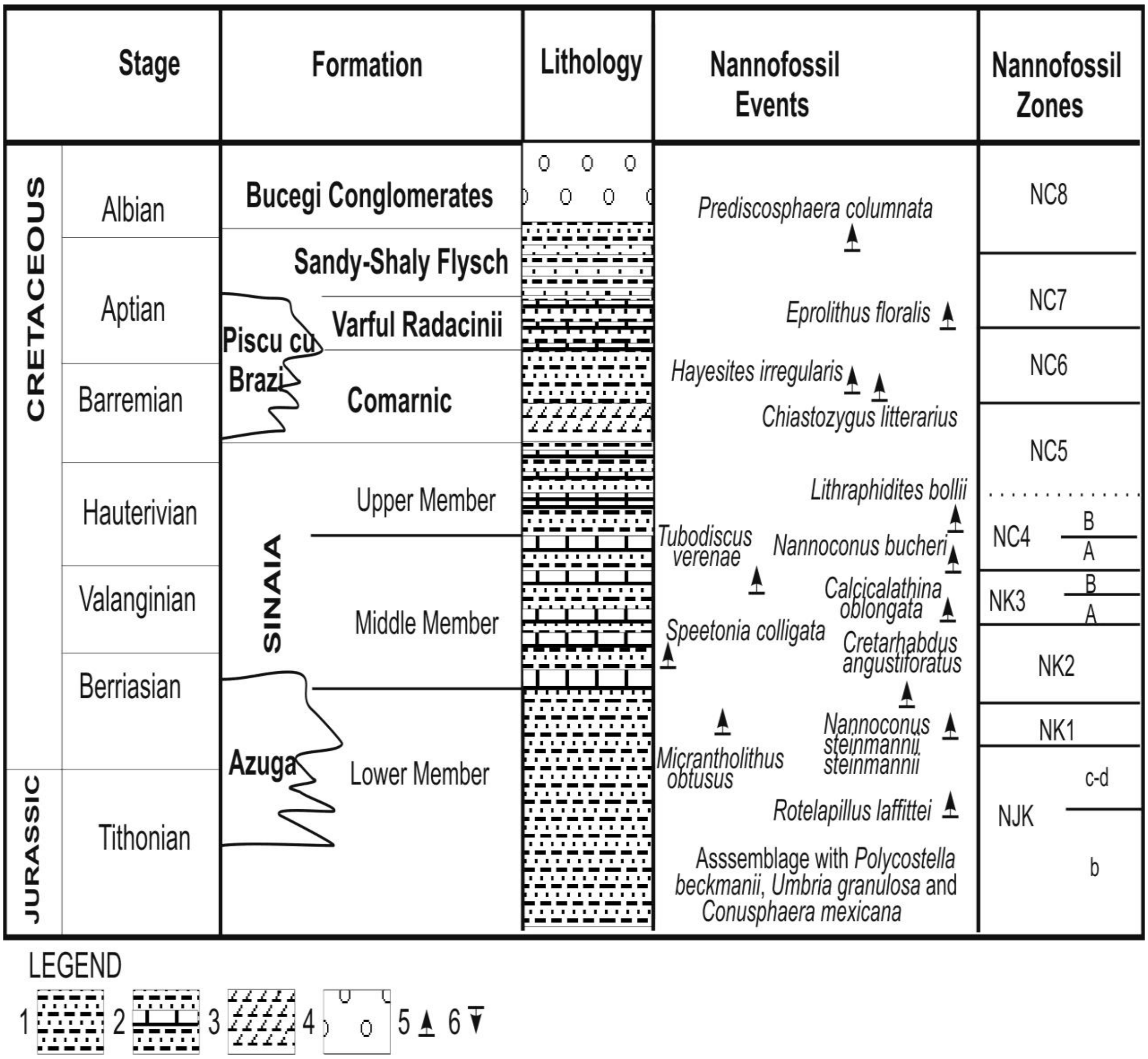

Fig. 5 - Lithology and biostratigraphy of the Lower Cretaceous deposits of the Prahova Valley (Ceahlău Nappe, Outer Dacides). Legend: 1 - turbidites; 2 - limestones; 3 - marlstones; 4 - conglomerates; 5 - first occurrence; 6 - last occurrence. Calcareous nannofossil zones NJK and NK after Bralower et al. (1989); NC after Roth (1983). Age assignment after Melinte, 1996; Melinte and Jipa, 2007.

The Oligocene is mainly represented by the Pucioasa Formation, mainly composed of dark-grey or brownish shales and thin bedded sandstones with parallel or crossed-lamination. Two intervals of an anoxic deposition, i.e., bituminous shales (= the Lower Dysodilic Shale Formation, Early Oligocene in age and the Upper Dysodilic Shale Formation, Early Miocene in age) are also present. The Oligocene turbidites are followed by thick piles of Lower Miocene molasse deposits, containing levels of gypsum and salt.

The lithological changes along the Prahova Valley are well expressed in the geomorphological features. Therefore, the landscape presents two distinct steps: the lower one, which is gently dipping, corresponds to the Barremian-Aptian turbidite deposits; the upper one, very steep, is composed of the Albian conglomerates.

From a tectonic point of view, the Prahova Valley crosses, towards the South of Predeal area, the very complicated structure of the Ceahlău Nappe (Fig. 6). From Predeal, the Ceahlău Nappe traverses the Timiş Valley. North of the Predeal town, the route crosses the Predeal Pass, an Eastern Carpathian mountain pass (elevation 1,033 m). It connects the Prahova River Valley to the south with the lowlands of Ţara Bârsei Depression. Predeal Pass is an important passage between the southern Romanian Province Muntenia (Wallachia) including the capital Bucharest and the central Romanian Province of Transylvania (its eastern part).

The deposits of the Ceahlău thrust and fold sheet were deformed during two main phases. The first compressional event took place at the end of the Early Cretaceous, within the upper Albian. Deformation peaked a second time in the latest Cretaceous, during the Laramian tectonics (late Campanian-early Maastrichtian), when the Ceahlău Nappe system was emplaced in the Eastern Carpathians over a part of the Moldavides (outer eastern thin-skinned nappes of the Eastern Carpathians). The age of this thrusting is documented by syn- to post-kinematic hemipelagic sediments discordantly covering the Ceahlău Nappe contacts, i.e., the latest Cretaceous marine variegated sediments of Gura Beliei Formation (Săndulescu, 1984; Neagu and Gerogescu, 1991; Melinte-Dobrinescu and Jipa, 2007). From the northern to the southern border of the Comarnic town, the road crosses the Bratocea and Comarnic digitations of the Ceahlău Nappe, along with some structures belonging to the Bobu and the Teleajen (=Convolute Flysch) nappes; the later is included in the Inner Moldavide Nappe System.

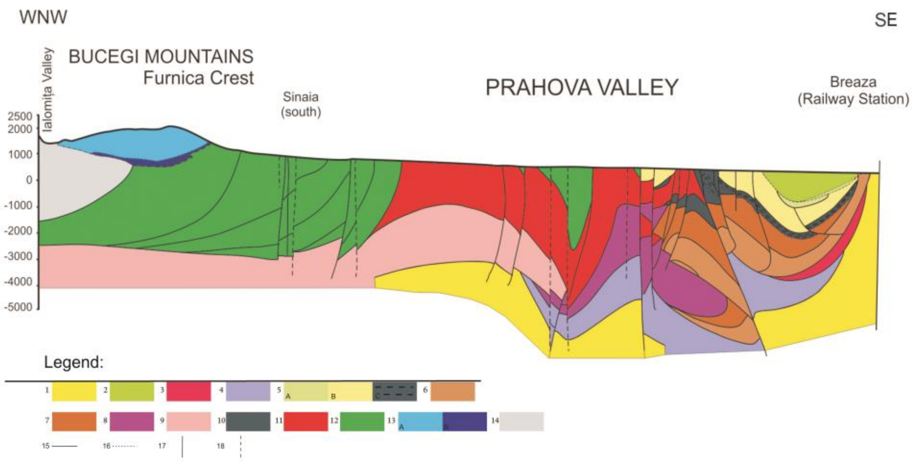

Fig. 6 – Structural section along the Prahova Valley, between Sinaia and Breaza localities and across the Bucegi Mts. (modified after Ştefănescu 1976 and 1995). Legend: 1 - Tarcău Nappe; post-tectogenetic cover of the units with Lower Miocene tectogenesis; 2 - Doftana Molasse; 3 - Variegated Clay Nappe; 4 - Audia Nappe; 5 - post-tectogenetic cover of the units with Early Laramian tectogenesis: A - Valea Caselor Facies; B - Şotrile Flysch; C - Gura Beliei Marls; 6 - Macla Nappe; 7 - Convolute Flysch (Teleajen) Nappe; 8 - Bobu Nappe; Ceahlău Nappe; 9 - Ciuc Digitation; 10 - Secăria Digitation; 11 - Comarnic Digitation; 12 - Bratocea Digitation; 13 - post-tectogenetic cover of the units with Mesocretaceous tectogenesis: A - Bucegi Conglomerates; B. Raciu Breccia and its equivalents; 14 - Getic Nappe; 15 - conformity; 16 - unconformity; 17 - longitudinal fault; 18 - transverse fault.

4. FIRST DAY OF THE FIELD TRIP, THE 12TH OF SEPTEMBER

The field trip starts from Bucharest, and follows the highway up to Ploieşti town, from where in enters the Prahova Valley. The first day is focussed on Cretaceous deposits that crop out along the Prahova Valley and its tributaries (Fig. 7).

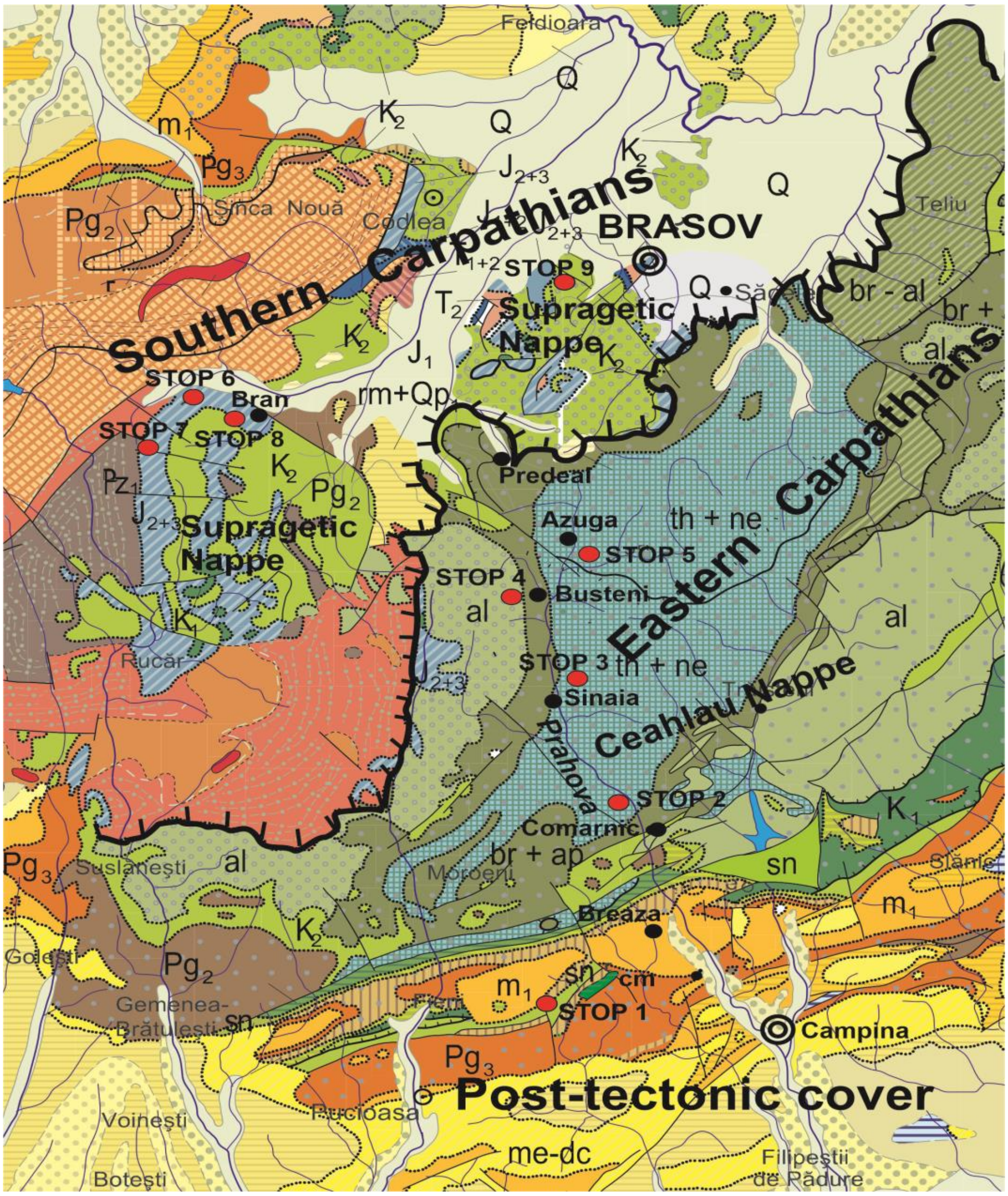

Fig. 7 – Geological map of the Carpathian Bend area. Legend: Q – Quaternary; me-dc (Maeotian-Dacian, Upper Miocene-Lower Pliocene); m_1 - Lower Miocene; Pg_2 – Eocene; Pg_3 – Oligocene; K_2 – Upper Cretaceous; sn – Senonian (Coniacian-Maastrichtian) al – Albian; br+ap – Barremian-Aptian); K_1 – Lower Cretaceous; th+ne – Tithonian-Neocomian; J_{2+3} – Lower-Middle Jurassic; J_{1+2} – Lower-Middle Jurassic; J_1 – Lower Jurassic; T_2 – Middle Triassic; T_{1+2} – Lower-Middle Triassic; Pz – Paleozoic (modified after The Geological Map of Romania, scale 1:1,000,000 published by the Geological Institute of Romania, 1973).

From Bucharest, following the highroad to Ploieşti, the route crosses the Moesian Platform, entering in the Carpathian Foredeep. Up to the Câmpina Town, the road traverses the Băicoi-Ţintea structure (Fig. 8), which is an exaggerated diapiric fold. To note that Romanian first oil processing refinery was arised in 1840 - a simple handmade equipment using rudimentary methods similar to distilling alcohol in a rustic boiler. Distillation on industrial scale started in 1857. The first mechanical drilling was used in 1857 in the Târgu-Ocna Town (Eastern Carpathians). Romania was the first country in the world to officially record an oil production of 275 tonnes in international statistics in 1857, followed by the United States in 1859, Italy in 1860, Canada in 1862 and Russia in 1863.

Fig. 8 – Petroleum Field in Carpathian belt of Romania in 1920 (www.romaniaoilandgas.com).

The flanks of the Băicoi-Ţintea structure contain significant Upper Miocene oil fields, tectonically screened on the salt faults. The Lower Miocene salt deposits (belonging to the Subcarpathian tectonic unit) penetrated through Upper Miocene-Pliocene sediments, reaching the surface.

Between Breaza railway station and Nistoreşti locality, the road crosses a wide syncline (Slănic Syncline), filled in with Lower Miocene (Burdigalian-Badenian) molasse deposits (=Doftana Formation). Just upstream of the Cornu locality, beneath the two limbs of the Slănic Syncline, the Cornu Formation (Early Miocene in age) crops out. The base of this unit encloses a well-bedded gypsum level. The gypsum beds are sometimes normally graded and show parallel or cross lamination; rarely, mecanoglyphs occurred. These features let to the idea that the gypsum beds were reworked by marine currents (Ştefănescu, 1995).

STOP 1 – Breaza de Sus

In this stop we will examine: (A) the Cenomanian deposits of the Dumbrăvioara Formation (B) the uppermost Cretaceous (Maastrichtian) Gura Beliei Formation and (C) the Oligocene concretions of the Breaza Geological Reserve (Fig. 9)

Fig. 9 – Location of STOP 1 in Breaza de Sus locality; A – Maastrichtian; B – Cenomanian; C – Oligocene (aerial image from www.googlemaps).

A - Maastrichtian red and white carbonate shales of the Gura Beliei Formation (Fig. 10)

The Gura Beliei Formation represents the post-tectonic cover of the Outer Dacide Nappe System (Ceahlău and Bobu nappes), and of the Inner Moldavides, lying on the overthrust planes among them (Săndulescu et al., 1981). The palaeodepth of Gura Beliei red beds was estimated around 200m. The basin where the red carbonate shales accumulated, as well as the whole area of the SE Eastern Carpathians, was characterized by a long subsidence period, which started, according to Ştefãnescu (1995), at the end of the Cretaceous. The red beds of the Gura Beliei Formation contain marls (60-70%), calcareous shales (30%), and limestones (10%), with abundant microfossils (foraminifera and coccoliths). Towards the upper part of the unit, sandstones occur in thin (cm) beds, containing quartz, lithic fragments (metamorphic schists, limestones), feldspar, micas, and heavy minerals, i.e., garnet, zircon, and apatite, all in a calcite cement (Melinte and Jipa, 2005). The calcareous nannofossil assemblages of the Outcrop A - Stop 1 are rich and diversified, containing several species with biostratigraphic significance (Fig. 11), such as *Micula prinsii, Micula murus*, *Arkhangelskiella cymbiformis*, *Ceratolithoides aculeus*, *Ceratolithoides kamptneri*, *Lithraphidites quadratus*, *Eiffellithus parallelus* and *Cribrosphaerella daniae,* indicating a late Maastrichtian age (biozones UC20c and UC20d of Burnett, 1998).

Fig. 10 – Red and white-grey calcareous shales of Gura Beliei Formation (STOP 1A).

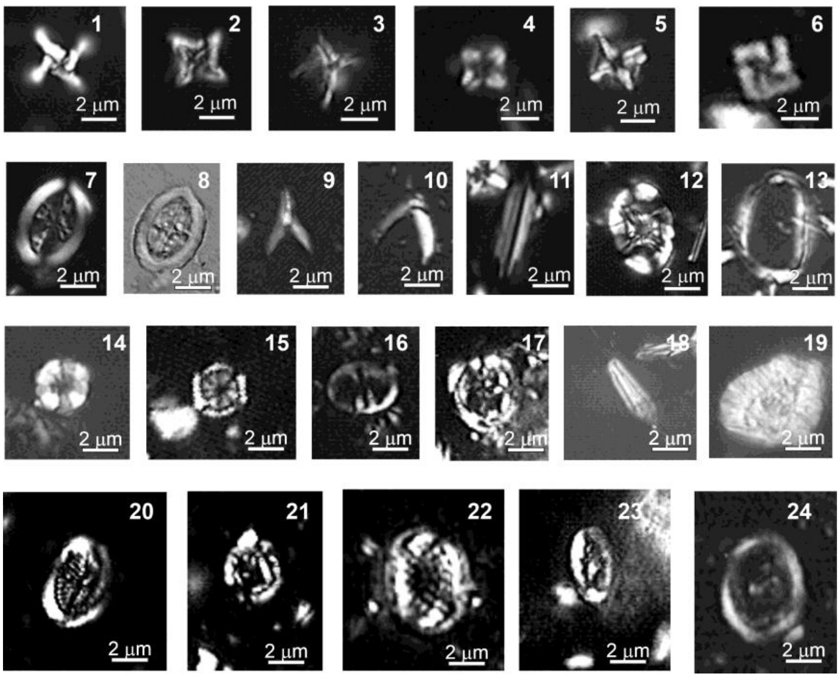

Fig. 11 – Calcareous nannofossil from Stop 1, LM (light microscope), crossed nicols: **MAASTRICHTIAN**: 1 – *Micula prinsii* Perch-Nielsen, 1979; 2 – *Micula murus* (Martini, 1961) Bukry, 1973; 3 – *Micula concava* Verbeek, 1976; 4 – *Micula cubiformis* Forchheimer, 1972; 5 – *Micula staurophora* (Gardet, 1955) Stradner, 1963; 6 – *Micula swastica* Stradner & Steinmetz, 1984; 7, 8 – *Arkhangelskiella cymbiformis* Vekshina, 1959; 9 – *Ceratolithoides aculeus* (Stradner, 1961); 10 – *Ceratolithoides kamptneri* Bramlette & Martini, 1964; 11 – *Lithraphidites quadratus* Bramlette & Martini, 1964; 12 – *Eiffellithus parallelus* Perch-Nielsen, 1973; 13 – *Cribrosphaerella daniae* Perch-Nielsen, 1973; **CENOMANIAN:** 14 – *Eprolithus floralis* (Stradner, 1962) Stover, 1966; 15 – *Corollithion kennedyi* Crux, 1981; 16 – *Tranolithus orionatus* Reinhardt, 1966; 17 – *Axopodorhabdus albianus* (Black, 1967) Wind & Wise 1983; 18 – *Lithraphidites acutus* Verbeek & Manivit *in* Manivit et al., 1977; 19 – *Nannoconus truittii* Brönnimann, 1955; 20 – *Cretarhabdus striatus* (Stradner, 1963) Black, 1973; 21 – *Prediscosphaera cretacea* (Arkhangelsky, 1912) Gartner, 1968; 22 – *Cribrosphaerella ehrenbergii* (Arkhangelsky, 1912) Deflandre in Piveteau, 1952; 23 – *Rhagodiscus angustus* (Stradner, 1963) Reinhardt, 1971; 24 – *Rhagodiscus asper* (Stradner, 1963) Reinhardt, 1967.

B - Cenomanian deposits of the Dumbrăvioara Formation post-tectonic cover

The Albian sediments of the Outer Dacides are covered by a thick pile of conglomerates (the Bucegi unit), followed by the hemipelagic variegated deposits (Fig. 12) of the Cenomanian Dumbrăviora Formation (separated also as the 'Variegated Clay Formation' in the SE Eastern Carpathians, according to Ştefănescu, 1995).

Commonly, granite, granodiorite and rhyolite clasts are known to occur at various Cretaceous intervals in the Outer Dacides and Moldavides, from the Albian up to the Maastrichtian. Their source was originally attributed to a presumed Cuman Ridge located within the flysch basin (Murgeanu, 1937). U-Pb zircon dating on Aptian-Albian breccias with granitoid and rhyolite clasts from the Moldavian nappes indicate an age of ca. 600 Ma (Roban et al., 2020), simitar to igneous intrusions into the continental Moesian Platform basement.

Fig. 12 – Cenomanian variegated hemipelagic deposits.

In Stop 1B, red marlstones and claystones (Fig. 12), Cenomanian in age (based on calcareous nannofossils – Fig. 11) granitoid and rhyolite clasts occur. U-Pb zircon analyses indicate an age of around 600 Ma (Lőrincz et al., 2022).

The source of the clasts could be the Eastern European Craton in the foreland of the East Carpathians: Moesian Platform, North Dobrogea, and the Scythian Platform or another terrane eroded and covered by the flysch nappes, possibly like the Brno-Silesian terrane (Lőrincz et al., 2022).

C - Miocene concretions in the Natural Reserve Breaza

Several m-thick concretions (described in Romanian geological literature as 'trovant' by Murgoci, 1907), are included in Breaza Geological Protected Area (Fig. 13). Due to their shape, people named these rocks 'living stones' or 'growing stones'.

The occurrence of the concretions requires sandy sediments, in addition to a significant flux of carbonate-bearing fluids, conditions fulfilled in the region due to the presence of Lower Oligocene-Miocene sandstones. Most concretions are spherical; some of them contain at their base microconglomerates with green schist clasts, a key element for the Eastern European Edge provenance. Probably, the Breaza concretions formed during early diagenesis processes.

Rarely, in the concretions, some macrofossils, such as gastropods (mainly *Cerithium* spp.) and bivalves may be found. Most of them are Eastern Paratethyan endemic species that belong to the genera *Mactra*, *Cardium,* and *Tapes*.

Fig. 13 – Concretions occurring in the Breaza Natural Reserve.

STOP 2 - Berriasian successions at Podul lui Neag (Neag Bridge), Comarnic locality

On the right bank of the Prahova Valley, at the exit from the Comarnic town towards Sinaia, the turbidites of the Middle Member of the Sinaia Formation occurred. A typical sandy-calcareous turbidite succession, strongly folded (Fig. 14) crops out. Incomplete Bouma sequences, consisting of horizontal- and cross-laminated grey calcareous sandstones, alternating with laminated siltstones and grey shales can be observed. The succession is capped by white marlstones or even limestones.

The mecanoglyphs indicate a transport direction from north to south (Jipa, 1980). On the geological maps, the Sinaia Formation is assigned in general to the Tithonian-Barremian interval (th-ne in Fig. 7). The sediments of the Middle Member frequently contain tintinnids, indicating a Berriasian in age (Pop, 1997). Based on calcareous nannofossils, the whole Middle Member occurring on large areas in the Prahova Valley basin was assigned to the late Berriasian - early Hauterivian interval (Melinte and Mutterlose, 2001; Melinte-Dobrinescu and Jipa, 2007).

Fig. 14 – The Middle Member of the Sinaia Formation cropping out at Neag Bridge (right bank of Prahova Valley).

The calcareous nannofossils identified in this outcrop contain besides long-ranging species, several nannofossils significant from a biostratigraphic point of view, such as *Rucinolithus wisei*, *Cretarhabdus conicus*, *Nannoconus kamptneri minor*, *Nannoconus steinmannii minor*, and *Speetonia colligata*, indicating a late Berriasian age. This calcareous nannofossil assemblage corresponds, according to Melinte and Mutterlose (2001), to the Calpionellopsis oblonga Calpionellid zone of Pop (1997). Considering the biostratigraphy, the succession exposed in Stop 2 represents the lower part of the Middle Member belonging to the Sinaia Formation, late Berriasian in age.

STOP 3 – Valanginian turbidites in Sinaia Town

In STOP 3 we will examine the turbidites of the Middle Member of the Sinaia unit, exposed at the northern exit of the Sinaia town. A particularity for this succession is that the beds are not folded (Fig. 15a), Commonly, the Middle Member contains successions highly tectonized. Bouma sequences could be seen, mainly consisting of sandstones showing parallel and crossed laminations, silts, and shales (Figs. 15a, b).

Rarely, cm- to dm-thick limestones/marlstones occur, along with cm-thick black shales levels, especially in the lower part of the studied section. These features suggest low-density turbidite currents with altering high density flows. Most likely, the architectures are typical of turbiditic lobes. The analysed vectorial sedimentary structures, such as flute casts, indicate a SE direction of the palaeo-flows.

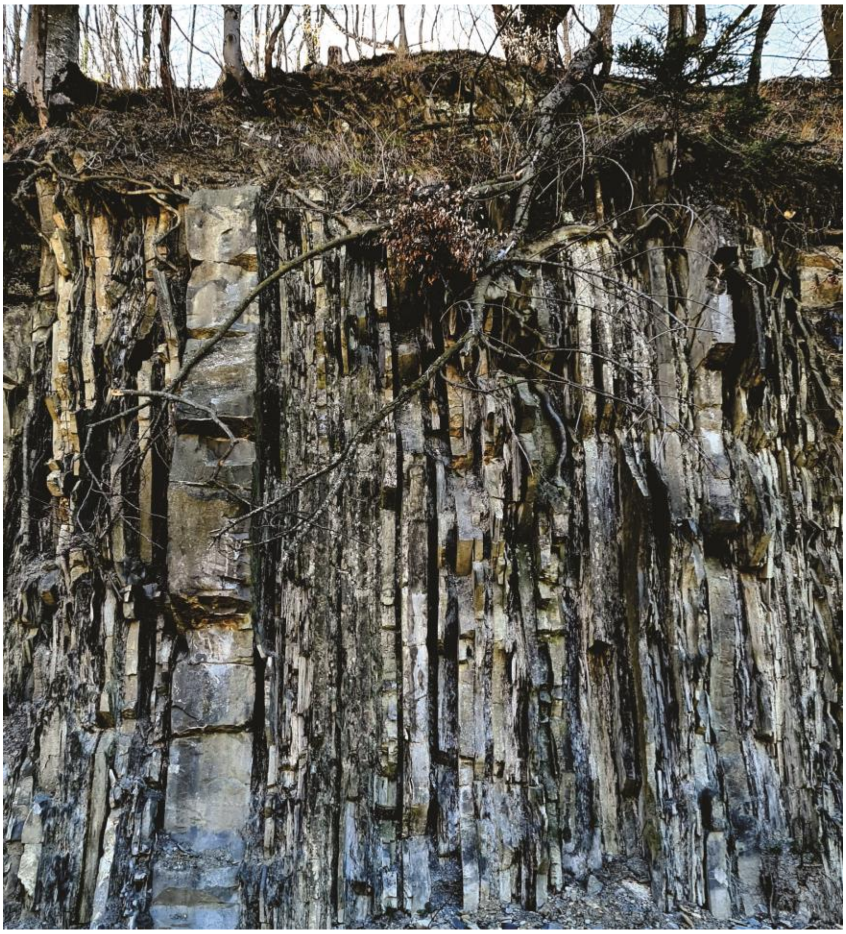

Fig. 15a – Lithology and sedimentology of the Middle Member of Sinaia unit exposed in Sinaia town.

The studied samples from this outcrop revealed the presence of diversified calcareous nannofossil assemblages, mainly containing Tethyan taxa, more related to warm surface-water. Among the identified nannofossils could be listed: *Calcicalathina oblongata*, *Cruciellipsis cuvillieri*, *Tubodiscus verenae,* and *Eiffellithus windii* (Fig. 16), besides other taxa which cover larger

Lower Cretaceous depositional intervals. The nannofossil biostratigraphy indicates a late Valanginian age for this succession.

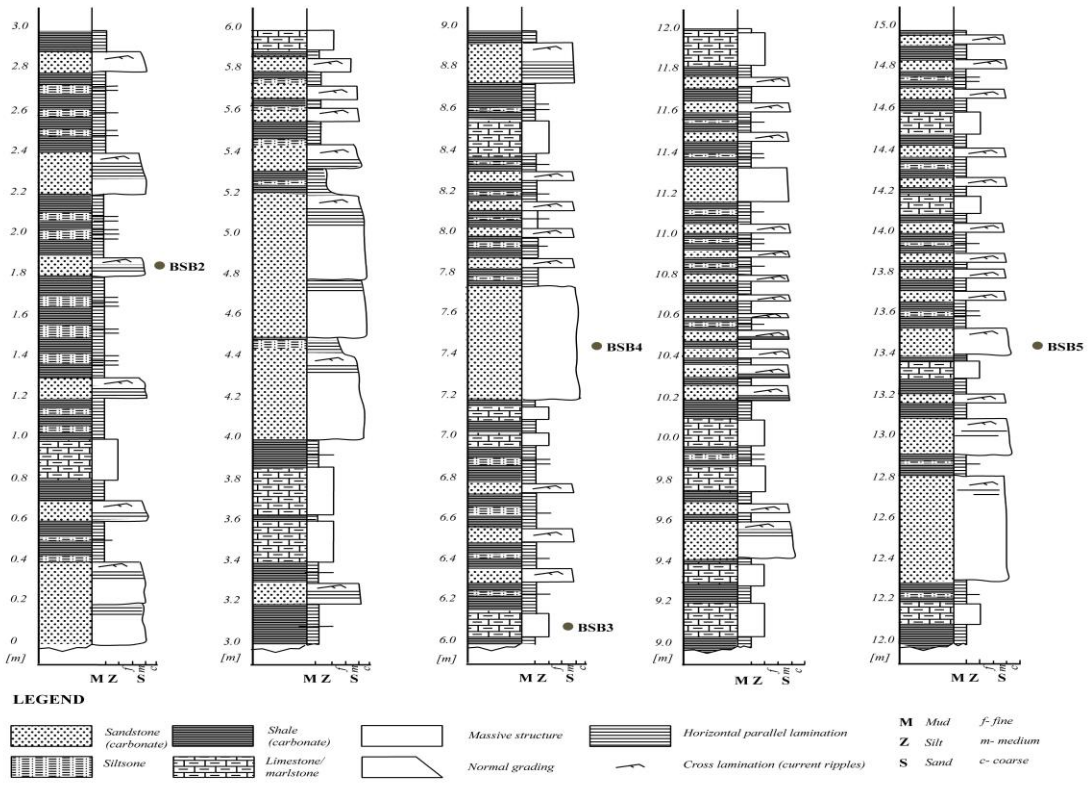

Fig. 15b – Lithology and sedimentology of the Middle Member of Sinaia unit exposed in Sinaia town.

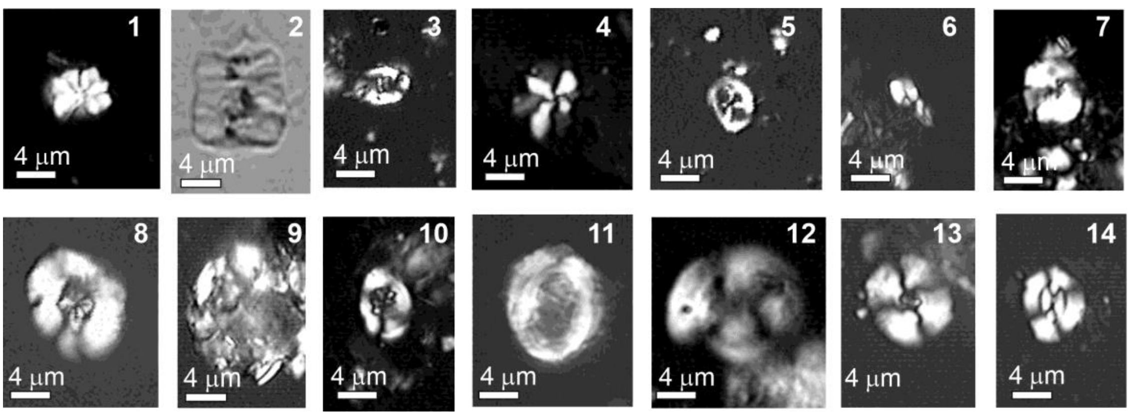

Fig. 16 – Valanginian calcareous nannofossils identified in STOP 3. 1 – *Rucinolithus sp*; 2 – *Nannoconus kamptneri* Brönnimann, 1955; 3 - *Eiffellithus windii* Applegate & Bergen, 1988; 4 - *Rucinolithus pinnatus* Bergen, 1994; 5 - *Staurolithites mutterlosei* Crux, 1989; 6, 7 - *Assipetra infracretacea* (Thierstein, 1973) Roth, 1973; 8 - *Cruciellipsis cuvillierii* (Manivit, 1966) Thierstein, 1971; 9 - *Calcicalathina oblongata* (Worsley, 1971) Thierstein, 1971; 10 - *Retecapsa angustiforata* Black, 1971; 11 - *Tubodiscus verenae* Thierstein, 1973; 12 - *Haqius circumradiatus* (Stover, 1966) Roth, 1978; 13 - *Watznaueria britannica* (Stradner, 1963) Reinhardt, 1964; 14 - *Watznaueria barnesae* (Black *in* Black & Barnes, 1959) Perch-Nielsen, 1968.

STOP 4 – Albian conglomerates at Buşteni

The Bucegi Formation is mainly composed of more than 2,000 m-thick pile of conglomerates. These are largely cropping out in the Bucegi Mts., a chain surrounding the Prahova Valley and which highest peak is Omu (= The Man), 2,504 m altitude. The Bucegi Mts. are remarkable for their extensive, unobstructed exposures of Albian conglomerates and sandstones, which have enhanced the massif alpine aspect and generated a significant tourism potential in the area. Due to erosional processes, several relief forms occur, such as the Sphinx (Fig. 17A), a Romanian national natural reserve, situated on the top of the Bucegi Mts., near the Buşteni town. It resembles the Egyptian Sphinx, from where it got its name.

The base of the Bucegi conglomerates is placed within the lower Albian, as the underlying unit 'Sandy-Shaly Flysch' is early Albian in age, based on the presence of Roth (1978) NC8 Calcareous Nannoplankton Zone (Melinte and Jipa, 2007; Briceag et al., 2008). The Bucegi Formation is covered by hemipelagic variegated sediments of the Dumbrăvioara unit; the base of the later unit is uppermost Albian, based on micropalaeontological data (Neagu, 1970, 1972; Melinte and Jipa, 2005; 2007). The sedimentological studies indicate that the Bucegi unit is mainly composed of orthoconglomerates, in which sub-rounded clasts, made by Upper Jurassic-Lower Cretaceous limestones and metamorphic rocks of the Southern Carpathians prevailed (Figs. 17B, C). Laminated coarse-grained sandstones also occur, especially at the base of the Bucegi Formation.

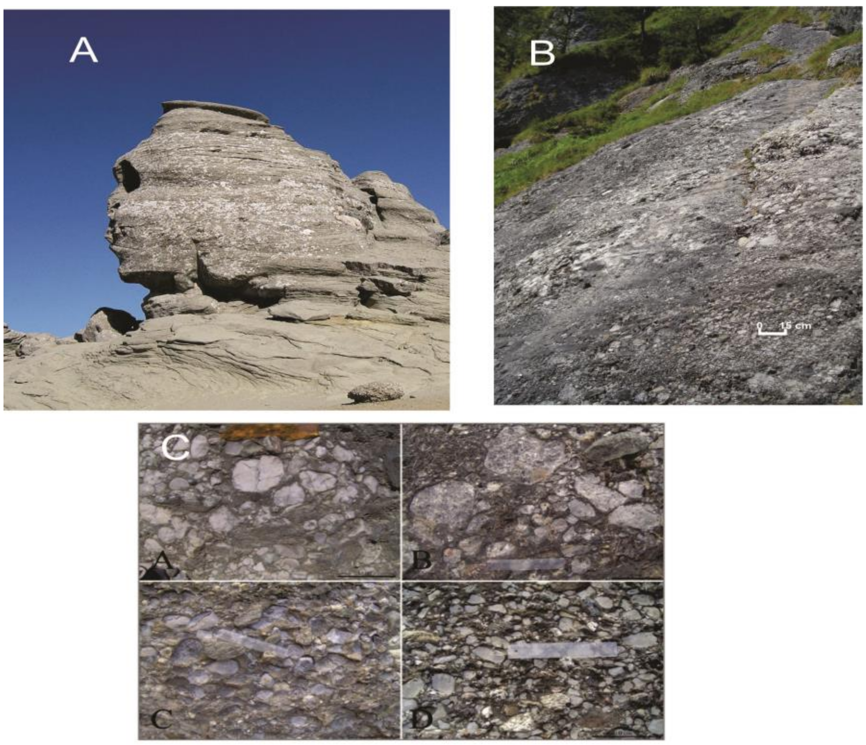

Fig. 17 – A - The "Sphinx" of the Bucegi Mts. made by Albian conglomerates, while its base is a structureless sandstone; B - Conglomerates of the Bucegi Formation in the Bucegi Mts.; C - Prevalence of limestone clasts over the matrix.

The conglomerates of the Bucegi unit were considered molasse deposits, representing the first term of the Ceahlău Nappe post-tectonic cover, linked to compressional events that occurred during the late Aptian to Albian times (Patrulius, 1969; Săndulescu, 1988). The tectonic processes have led to intense folding, accompanied by the deposition of coarse sediments, such as the breccias and conglomerates.

Other studies (Jipa, 1984; Olariu et al., 2014) challenged this hypothesis. They assumed that the Bucegi Formation was formed across the shallow to deep-water basin in a syntectonic regime. Possibly, the deposits were delivered from the erosion of the carbonate and metamorphic deposits to the east and north *via* rivers and subaerial mega-debris flows, gradually building a narrow (10–20km) shelf as a 'bridge' between the hinterland and the deepwater slope fronting the basin (Olariu et al., 2014).

The authors assumed the existence of a "sorting factory", where the sediments are reworked by multi-directional basins of several hundred meters, building the shelf platform (Olariu et al., 2014). Their shelf-to-slope model for the Bucegi Formation (Fig.18) suggests the presence of the shelf break zone.

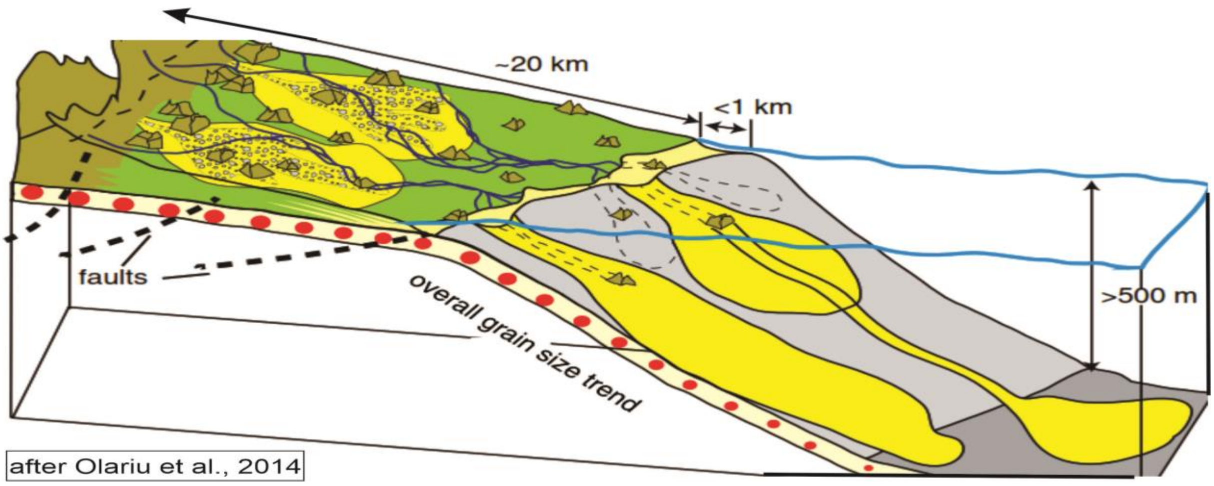

Fig. 18 – Model of the Bucegi conglomerates deposition. Low-stand stage of the basin margin with coarse river feeding the stage basin margin with the fine sediments (sandy deposits stored on the shelf).

The provenance of clastic material is the Getic basement, was proven by U-Pb detrital zircon ages. The 460 Ma peak is a common feature of the analyzed samples from the conglomerates belonging to the Bucegi Formation and the pre-alpine basement of the Dacia block (Getic Nappe). Recently, Variscan metamorphism of pre-alpine Getic basement occurring in the Southern Carpathians is well documented through the U-Pb ages of monazite (Fig. 19) extracted from the conglomerate of the Bucegi unit (Stoica et al., 2016). A recent tectonic and palaeogeographic reconstruction (Roban et al., 2020) assumed that the Bucegi clastic syn-tectonic wedge was situated at the contact between Dacia Block and Danubian Unit (Fig. 20).

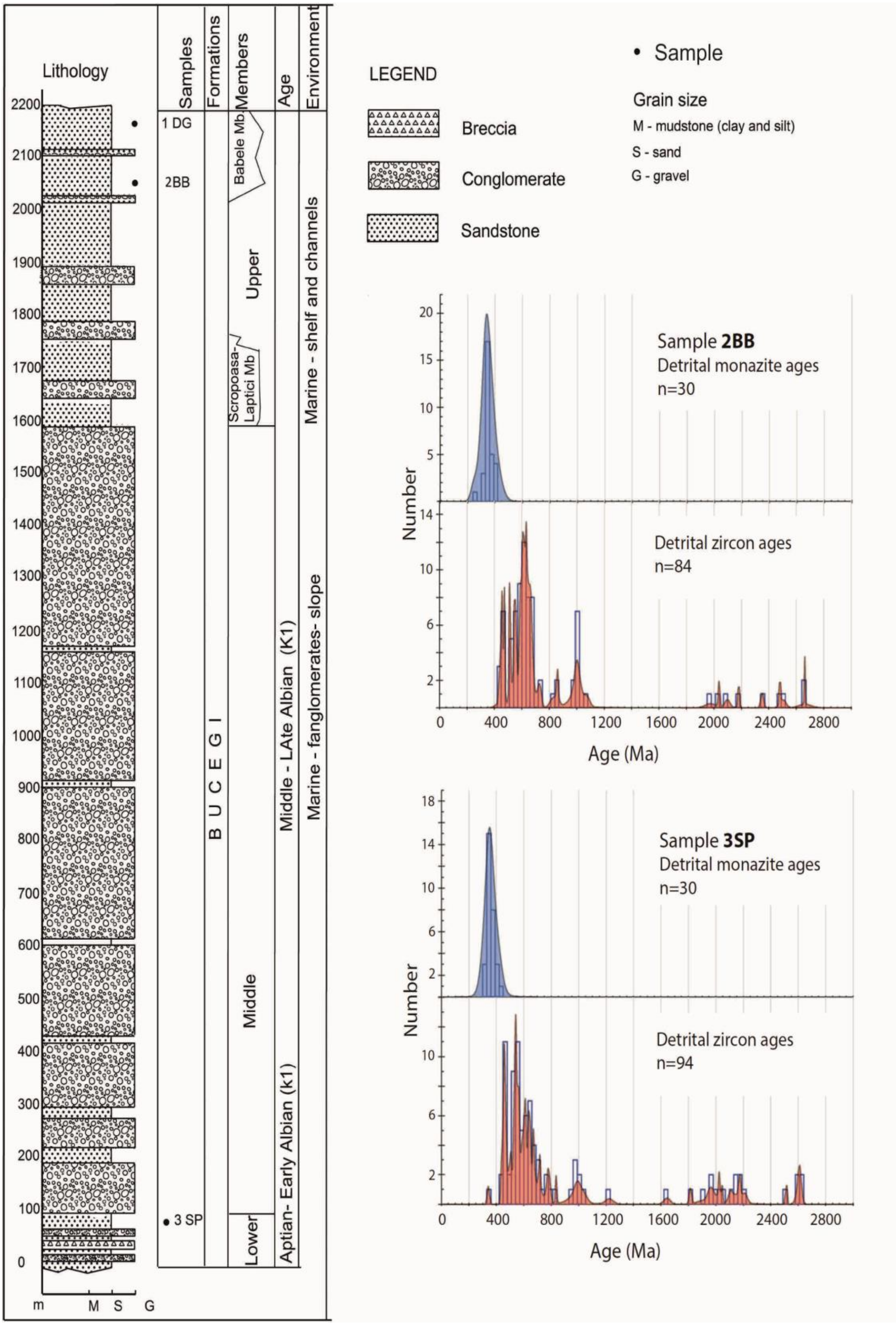

Fig. 19 – Left side. Schematic stratigraphic section of Lower Cretaceous Bucegi Formation showing the depositional context and the samples location (drawn using data from Olariu et al., 2014). Right side. U-Pb detrital zircons and monazite ages. The age distribution is consistent with pre-alpine Getic Basement. Detrital monazite age indicates the Variscan metamorphism of the Getic basement rocks (from Stoica et al., 2016).

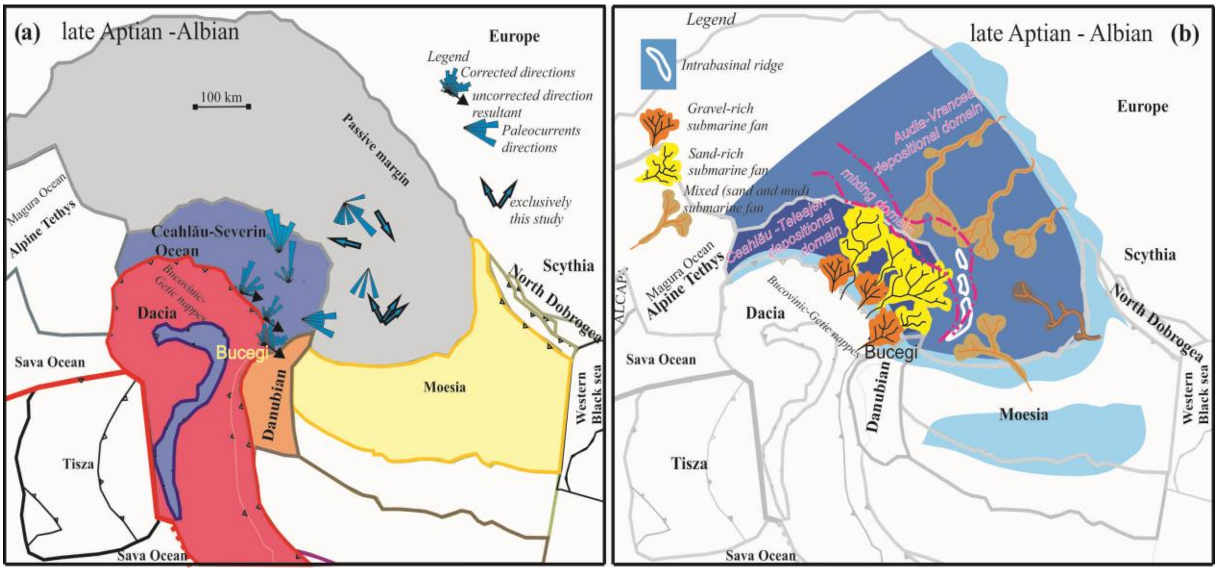

Fig. 20 - Tectonic (a) and palaeogeographic (b) reconstructions during the late Aptian-Albian of Ceahlău-Severin Ocean (Roban et al., 2020). Bucegi clastic syn-tectonic wedge is situated at the contact between Dacia Block and Danubian Unit.

STOP 5 – Tithonian-Berriasian Azuga Formation at Azuga

Towards the base of the Sinaia Formation, red and green shales, sandstones and marlstones usually bearing mafic igneous rocks (= the Azuga Formation) occurred – Fig. 21. The occurrences of concordant lava flow within the Azuga Formation, associated with basic tuffs and jaspers, indicate that the volcanism was contemporaneous with the beginning of the Sinaia turbidite sedimentation, within the Jurassic-Cretaceous boundary interval.

The presence of the Azuga Formation was linked by the existence of an immature island arc in the Romanian Carpathian bend area, with an active volcanism, particularly during the end of the Jurassic, concomitantly with the deposition of Tithonian-upper Berriasian turbidites belonging to the Lower Member of the Sinaia Formation. Hence, the deposition of the Azuga and Lower Sinaia formations seems to have been contemporary with extensional volcanism (Săndulescu, 1984; Ştefănescu and Micu, 1987), but the magnitude of the extension is still under debate.

Fig. 21 - Red shales, carbonate shales, and marlstones bearing cherts of the Azuga Formation cropping out in Prahova Valley.

From Azuga, the field trip follows the route to the north up to the Predeal town, turns towards NW to the Râşnov locality and afterward enters the Dâmbovicioara Pass.

Overnight at Fundata, in the Dâmbovicioara (Rucăr-Bran) Pass.

Surrounded by the Bucegi Mountains and the Piatra Craiului Mountains, Fundata commune, attested as locality in 1734, is situated at altitude of 1,360 m, being the highest commune in Romania. Fundata lies on the southern border of Brașov County, in the middle of Dâmbovicioara (Rucăr-Bran) Pass.

In August 1916, when troops from the Romanian Old Kingdom entered Austria-Hungary , the first village they took was Fundata, also capturing their first prisoners there and suffering their first battle death. Nowadays, the locality is known for its traditional lifestyle of herding sheep and cows, augmented by tourism. There is an annual festival held around July 20, feast of the prophet Elijah, called Nedeia Munților ("Mountain Celebration").

5. THE SOUTHERN CARPATHIANS

The Southern Carpathians extend on 500 km length from the Prahova Valley in Romania up to the Timoc Valley in Serbia. This mountain chain has been divided into several groups, their highest peak being Moldoveanu in the Făgăraş Mts., situated at 2,544 m altitude.
The Southern Carpathians are bordered by Getic Depression (their Foreland) and the Moesian Platform to the S and by the Transylvanian Depression towards the N (Fig. 1), covering an area of around 2,000 km^2.

This Carpathian belt consists of an Alpine nappe pile belonging to three major tectonic units (Săndulescu, 1984): (i) *the Marginal Dacides*, represented by the Danubian nappes, composed of a pre-Alpine crystalline basement and an Upper Paleozoic to Mesozoic sedimentary cover; (ii) *the External Dacides*, composed of the Severin Nappe, with Lower Cretaceous turbidites and ophiolites and (iii) *the Median Dacides*, i.e., the Getic and the Supragetic nappes, with a pre-Alpine metamorphic basement and an Upper Paleozoic-Mesozoic sedimentary cover (Fig. 22). The nappe stacking started within the late Early Cretaceous, when the overthrust of the Supragetic units on the top of the Getic Unit took place, along with the Getic Unit over the Severin Nappe. The nappes of the Southern Carpathians were involved also in Late Cretaceous, i.e., the Laramian, tectonic phases, The whole nappe pile of the Southern Carpathians was subsequently overprinted by Paleogene and Neogene wrenching along steep dextral strike-slip faults (Maţenco et al., 1997; Iancu et al., 2005).

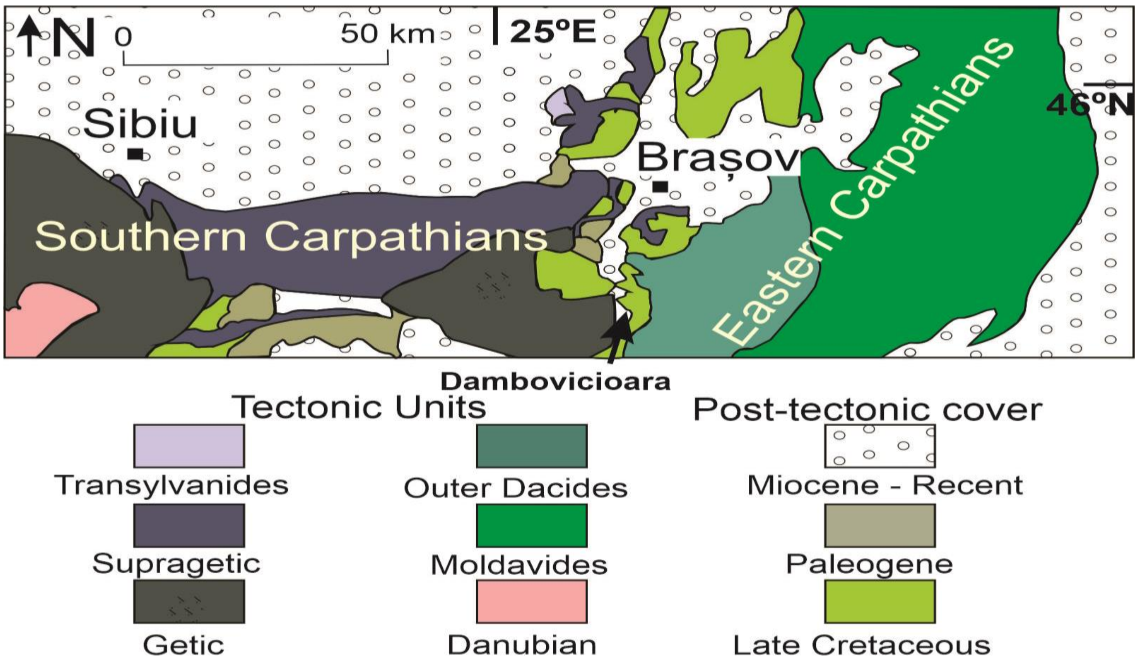

Fig. 22 – Geological map of the southern Eastern Carpathians and eastern Southern Carpathians separated by the Dâmbovicioara Passing (redrawn after Patrulius, 1969 and Săndulescu, 1984).

6. ITINERARY OF THE SECOND DAY 13TH OF SEPTEMBER

The Dâmbovicioara region (often described in the Romanian geological papers as 'the Dâmbovicioara Couloir') represents, from a geographical point of view, a passage between the Eastern Carpathian and the Southern Carpathians and a connection between the two historical Romanian provinces, Muntenia (=Wallachia) and Transylvania. Along the Dâmbovicioara region, the Piatra Craiului Massif (belonging to the Southern Carpathian structures) could be seen towards W, while towards E the crests of the western part of the Bucegi Mountains could be observed.

The highest peak (2,244 m) of the Piatra Craiului Massif is La Om (also known as Piscul Baciului). The massif has several peaks over 2,000 m altitude, such as Padina Popii (2,025 m), Vârful Ascuţit (2,150 m), Ţimbalul Mare (2,177 m), Vârful dintre Ţimbale (2,170 m), Sbirii (2220 m), and Vârful Căldării Ocolite (2,202 m).

Due to its natural attractions, including caves, gorges, and magnificent landscapes, as well as several protected faunas and floras, a natural park, namely the "Piatra Craiului Reservation", was established in 1938 in this area, on over 1,200 hectares.

Geologically, the Dâmbovicioara area (known also as Rucăr - Bran) belongs to the eastern part of Southern Carpathians. This area was assigned by Patrulius (1969) to a syncline structure, oriented SW-NE, placed between the Făgăraș and Iezer-Păpușa Mts. to the west and Leaota, Bucegi and Postăvaru Mts. Tectonically, the Dâmbovicioara area is located on the eastern part of the Getic Nappe, one of the major geotectonic units of the Median Dacides in Romanian Carpathians, considered to be a strongly deformed European continental margin (Săndulescu 1984, 1994). In the Southern Carpathians, the Median Dacides include wide areas of pre-Mesozoic metamorphic-magmatic basement complexes and Palaeozoic to Mesozoic sedimentary successions (Iancu et al., 2005).

The sediments of the Getic Nappe are Triassic–Early Cretaceous in age, being preserved in several areas of the Southern Carpathians. In the eastern part of the Southern Carpathians, where Dâmbovicioara area is located, the Mesozoic rocks included in the Getic/Supragetic Nappes are mainly of Jurassic-Early Cretaceous in age. The Middle and Upper Jurassic deposits (nodular limestones) exceed the spreading areal of the Lower Jurassic sediments (mainly microconglomerates and bedded sandstones); the Jurassic formations occur south of the Bran threshold (in the Dâmbovicioara area) and in the western part of the Bucegi Mts., where they directly covered the crystalline schists of the Leaota Series (Patrulius, 1969).

During Late Jurassic-Early Cretaceous times, the carbonate deposition took place within a large, but fragmented carbonate platform, which has been formed during an extensional tectonic regime. Deposits of this carbonate platform are known to occur in the whole Southern Carpathian area. Patrulius et al. (1976) interpreted the overall Upper Jurassic to Lower Cretaceous carbonate rocks as formed within several carbonate platforms, grouped under the name Getic Carbonate Platform. Structural, sedimentological, and palaeontological data (Patrulius, 1960; Neagu, 1975; Patrulius and Avram, 1976; Avram et al., 1996; Avram and Melinte, 1998; Barragán and Melinte, 2006; Bucur et al., 2011; Grădinaru et al., 2016) indicate the drowning of the carbonate platform of the Southern Carpathians in the Aptian.

The Dâmbovicioara area contains one of the richest macrofaunas (especially ammonites) in the Romanian Carpathians. Palaeontological studies started already in the 19th Century (Herbich, 1888; Popovici-Hatzeg, 1898), continued at the beginning of the 20th Century (Jekelius, 1938; Oncescu, 1943) and significantly advanced with the investigations of Patrulius (1969). More recent investigations on Early Cretaceous ammonite faunas from the region belong to Avram et al. (1996), Avram and Melinte (1998) and Avram (1999).

The Upper Jurassic (Kimmeridgian)-Lower Cretaceous (lower Valanginian) deposits, described as the Cheile Dâmbovicioarei Formation, included in the Getic Carbonate Platform of Patrulius (1969), are made of thick white limestones, which in some areas (i.e., Piatra Craiului) lie directly on the crystalline basement.

Rich ammonite assemblages, one of the most diversified in the Romanian Carpathians, of Kimmeridgian, Tithonian, Berriasian and Early Valanginian ages (Patrulius 1969; Patrulius and Avram, 1976), have been identified in these sediments. The calcareous algae formed typical associations for reef slopes and internal platforms. The latter can be subdivided into: (1) restricted environments (low-energy subtidal-intertidal) dominated by rivulariacean type cyanobacteria, and (2) open-marine environments (moderate to high-energy subtidal), in which mainly dasycladalean algae occur (Bucur, 1999; Mircescu et al., 2014).
Overall, the Kimmeridgian-Lower Valanginian carbonate succession consists of deposits formed in various depositional palaeoenvironments, from platform margin to internal platform carbonate deposits. Jointly with the progradation of the carbonate platform, the water became shallower. The sea-level changes have directly influenced the flora and fauna development. In the restrictive environments, cyanobacteria flourished, while some dasycladalean algae such as *Clypeina sulcata*, *Salpingoporella annulata*, and *Clypeina parasolkani* developed optimally in the lagoons (Bucur et al., 2009; Mircescu et al., 2014).

The Upper Valanginian-Lower Aptian succession, described as the Dâmbovicioara Formation, transgressively overlies the Upper Jurassic-lower Valanginian sediments. It consists of three members (Patrulius and Avram, 1976; Avram et al., 1996), as follows (Fig. 23):

(i) The Cetatea Neamţului Member, Late Valanginian *pro parte*, around 50 m thick, which starts with a condensed coquina bed containing ammonites, bivalves, and brachiopods; locally, glauconite-rich levels are present; the unit is mainly made of limestones.

(ii) The Dealul Sasului Member, late Valanginian - late Hauterivian in age, consists of marls and fine-grained calcarenites with cherts, in places with centimetre-thick gluconite-rich levels. The rich ammonite assemblages, identified especially in the marly levels, range from the Trinodosum Zone up to Balearis Zone.

(iii) The Valea Muierii Member, late Hauterivian-early Aptian in age, is built up of marls, limestones, including reefal ones, and calcarenites. The ammonite assemblages extend from the Angulicostata Zone up to Weissi Zone. Rich microfloras and nannofloras have been found in this unit (Neagu, 1972, 1975; Barragán and Melinte, 2006). A sea-level rise has been identified (Avram & Melinte, 1998; Barragán and Melinte, 2006) in the latest Barremian, based on mixed Tethyan and Boreal macrofaunas (ammonites) and calcareous nannofossils. This event has been succeeded by the restoration of a shallow-marine environment in the earliest Aptian. Subsequently, a major change occurred during the early Aptian when reef limestones and calcarenites were completely replaced by marl-dominated sequences containing mixed Tethyan, Boreal and cosmopolitan floras and faunas, probably because of the early Aptian global sea-level rise.

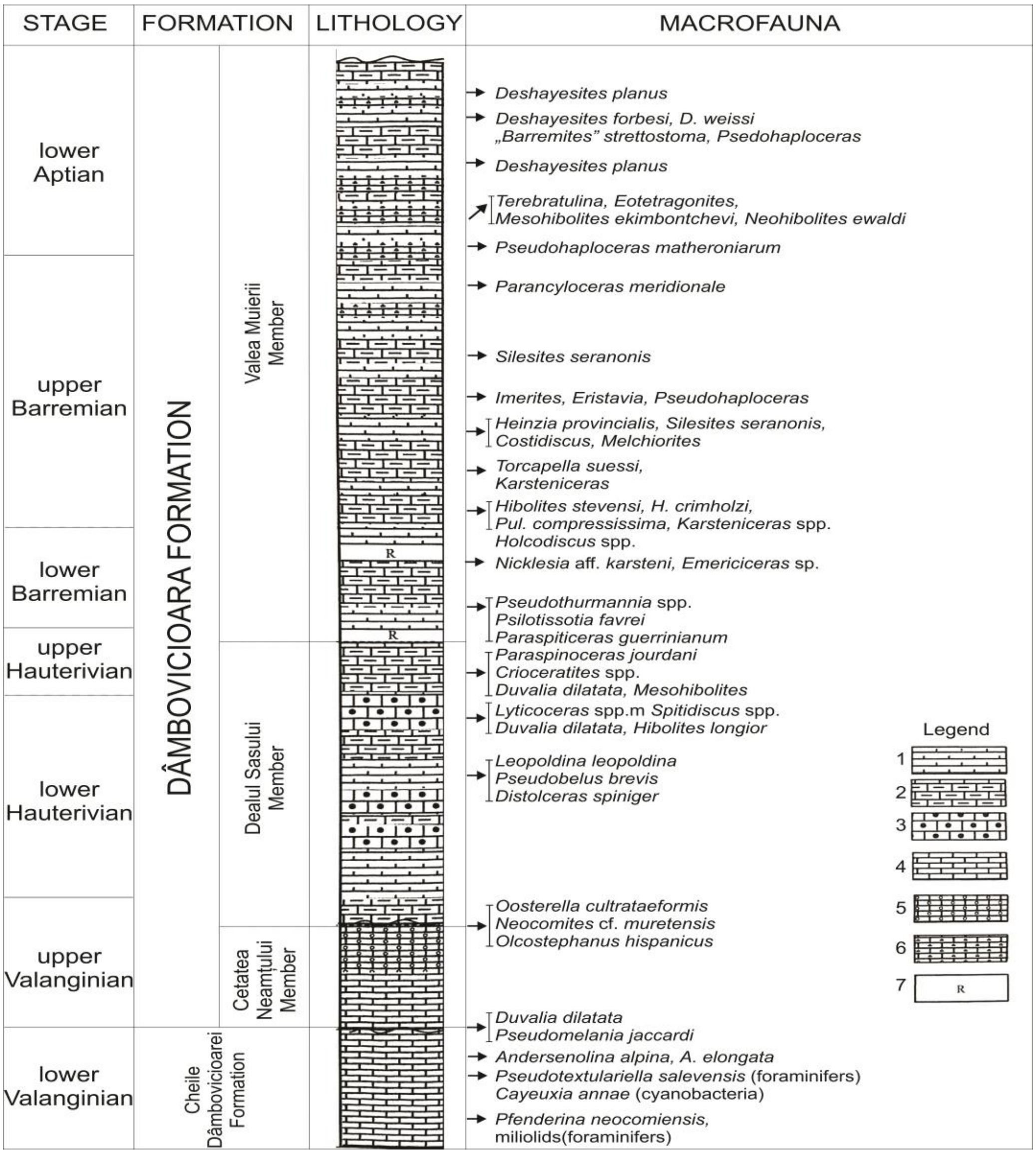

Fig. 23 - Litho- and biostratigraphy of the Lower Cretaceous deposits of the Dâmbovicioara region (after patrulius, 1969; Avram et al., 1996 and Avram and Melinte, 1998).
Legend: 1 - Marls; 2 - Argillaceous limestones; 3 - Limestones with cherts; 4 - Limestones; 5 - Oncolite limestones; 6 - Calcirudites; 7 - Reef limestone fragments.

The Dâmbovicioara Formation is followed by the Gura Râului Formation (late Aptian-Albian in age – Patrulius, 1969). This is mainly composed of conglomerates. It is exposed only in the northern part of the Dâmbovicioara region (i.e., between the Brusturet-Ciocanu and the Bran-Zărneşti alignments).

The first term of the post-tectonic cover of the Getic Nappe from the Dâmbovicioara region is the Braşov Formation (late Albian – Cenomanian in age), which is composed of conglomerates and sandstones and covers a morphological and structural palaeorelief with grabens and horsts (Patrulius and Avram, 1976). On the Bran-Măgura Mică threshold, at the northern extremity of the Dâmbovicioara region, the Braşov Formation occurs exclusively as a polymictic facies, including megabreccias with limestone klippen.

The youngest marine sediments so far known in the region are the grey-whitish marls, Cenomanian in age, described as 'Radiolarian Shales' (Patrulius, 1969; Dumitrică, 1975).

STOP 6 – **Panoramic view of the Cretaceous deposits in Dealul Sasului**

This stop is situated in the southern slope of Sasului Hill, where the road is enlarged, above the ruins of a small fortress, namely 'Cetatea Neamţului' (the German Fortress) or 'Cetatea Oraţii'. This small castle was built to defend the old commercial route between Wallachia and Transylvania.

The stop offers a panoramic view of the Upper Jurassic-Lower Cretaceous successions, including their complicate tectonic features, characterized by several graben and horst structures (Fig. 24). The grabens and horsts formed during the Late Jurassic-Early Cretaceous extensional regime (Patrulius, 1969).

Within the Aptian-Albian interval, a reactivation of the graben and horst structures took place, due to the intense tectonic activity in the area during the mid Cretaceous tectonic phases. Hence, the horsts contain older deposits, i.e., Upper Jurassic-Lower Cretaceous sediments, while the grabens are filled with siliciclastic upper Aptian-Cenomanian deposits. Around Cetatea Neamţului ruins, a complete succession of Upper Jurassic - Hauterivian is exposed; the oldest deposits, Tithonian-early Valanginian in age, are made by limestones, biocalcarenites and biosparites, topped by a hard-ground, and followed by limestones.

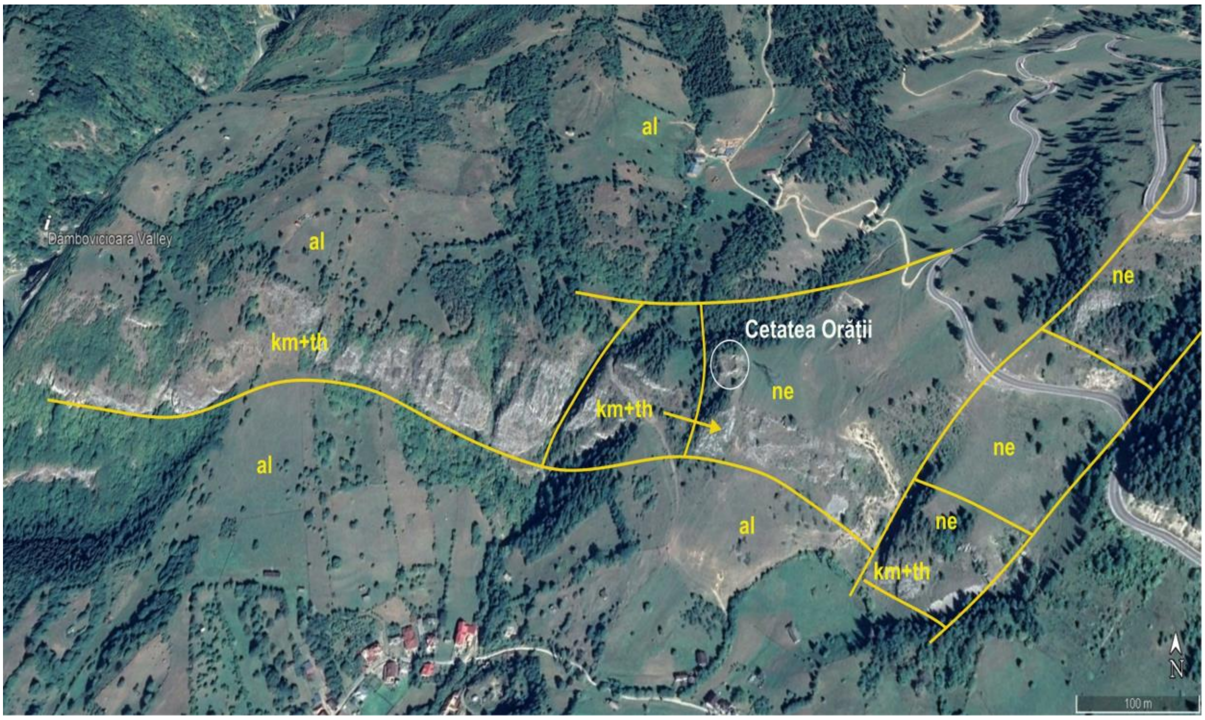

Fig. 24 - Horst and graben structures in the Dealul Sasului southern slope, as seen from the Panoramic view. Tectonics after Patrulius et al. (1969).

Along the road, nearby the coach parking, the upper part of the Dealul Sasului Member, made of cherts and calcarenites, late Valanginian - late Hauterivian in age, is exposed. This unit underlies the marls of the Valea Muierii Member and the upper Albian conglomerates. The lower part of the Dealul Sasului Member crops out in the highway cutting, at around 250-300 m south of the parking, in both banks of a creek. Marls with Valanginian ammonites, i.e., *Himantoceras trinodosum*, *Leopoldia leopoldina* and *Haploceras desmoceratoides* crop out.

Within the Lower Cretaceous intervals, patch reefs occurred. The stratigraphic position of these is well constrained by the surrounding marls with cephalopods interlayered with carbonate deposits containing benthic foraminifera and calcareous algae (Patrulius, 1969; Neagu, 1975; Patrulius et al., 1976; Avram et al., 1996). The microfacies and microfossil assemblages of the reef buildups were described in detail by Bucur et al. (2011) and Bucur et al. (2017).

STOP 7 – Uppermost Jurassic-Lower Cretaceous limestones in Cheile Dâmbovicioarei (Dâmbovicioara Gorges)

To reach this stop, we leave DN73 National Route and take a county route northward, to the Dâmbovicioara Gorge and Dâmbovicioara cave. The gorges, 2 km in length, are imposing, due to the vertical walls or even bent over bed, with heights exceeding 200 m, in some places.

The Dâmbovicioara Gorges (Fig. 25), extending on around 3 km on the Dâmbovicioara Valley that is a left-side tributary of the Dâmbovița Valley, traverses the uppermost Jurassic-Lower

Cretaceous sediments of “Cheile Dâmbovicioarei limestone” (= Cheile Dâmbovicioarei Formation, Patrulius, 1976; Patrulius & Avram, 1976).
The limestones of the Cheile Dâmbovicioarei constitute large outcrops with a stratigraphic thickness up to 400 m (Patrulius et al., 1980). The sediments of the Cheile Dâmbovicioarei Formation exposed in gorges were divided in three units: (i) reefal limestones; (ii) intraclastic/bioclastic-dominated shoals and (iii) peritidal limestones (Săsăran et al., 2017). Additionally, marlstones with with reefs, reef limestones and calcareous breccia could be also encountered. Sedimentologically, mudstones and packstones were observed (Fig. 26).

Coral-microbial boundstones with abundant corals and microbial crusts is the main type facies. The biotic compounds include branching and lamellar corals which are intensely encrusted by problematic microorganism and syndepositional radiaxial-fibrous cements, along with sponges, peloidal microstromatolitic crusts, microthrombolites and problematic microorganisms such as *Crescentiella morronensis* (Crescenti), *Radiomura cautica* (Senowbari-Daryan & Schäffer, *Koskinobullina socialis (*Cherchi and Schroeder), and *Lithocodium aggregatum* (Elliott). The dasycladalean algae are represented by the species *Steinmanniporella kapelensis* (Sokač and Nikler) and *Rivularia*-type cyanobacteria (Săsăran et al., 2017 – Fig. 27).
Within the earliest Cretaceous, i.e., Berriasian-Valanginian interval, mudstones to pelletal-intraclastic packstones, in places with porostomatic nodules (A. Baltreş, unpublished data) were deposited. The upper part of the succession exposes interbedded mudstones and packstones, with sparsporostomatic nodules, and, in places, crowded shells of gastropods, i.e., *Nerinea* spp.

Fig. 25 — The Dâmbovicioara gorges, cutting the Tithonian – Valanginian limestones.

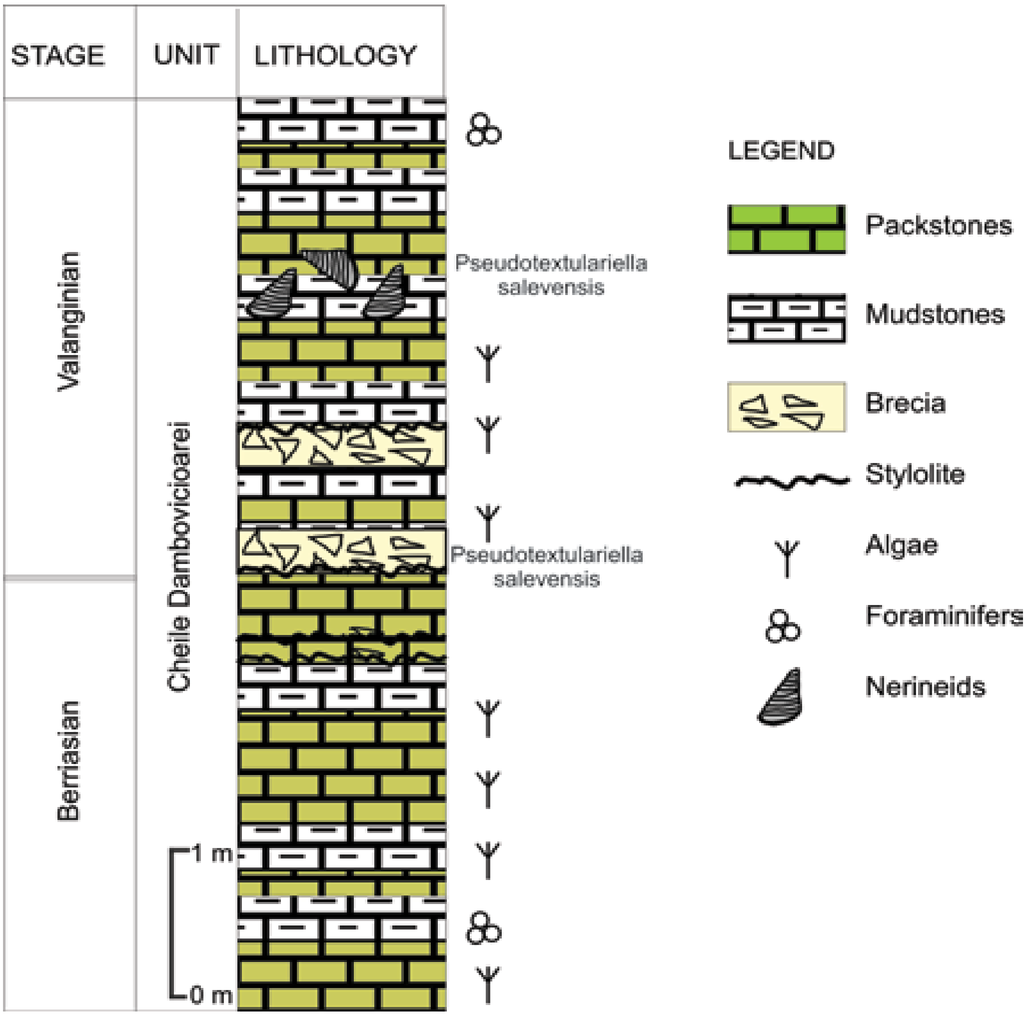

Fig. 26 – Berriasian-Valanginian succession in Cheile Dâmbovicioarei (after Avram et al., 1996).

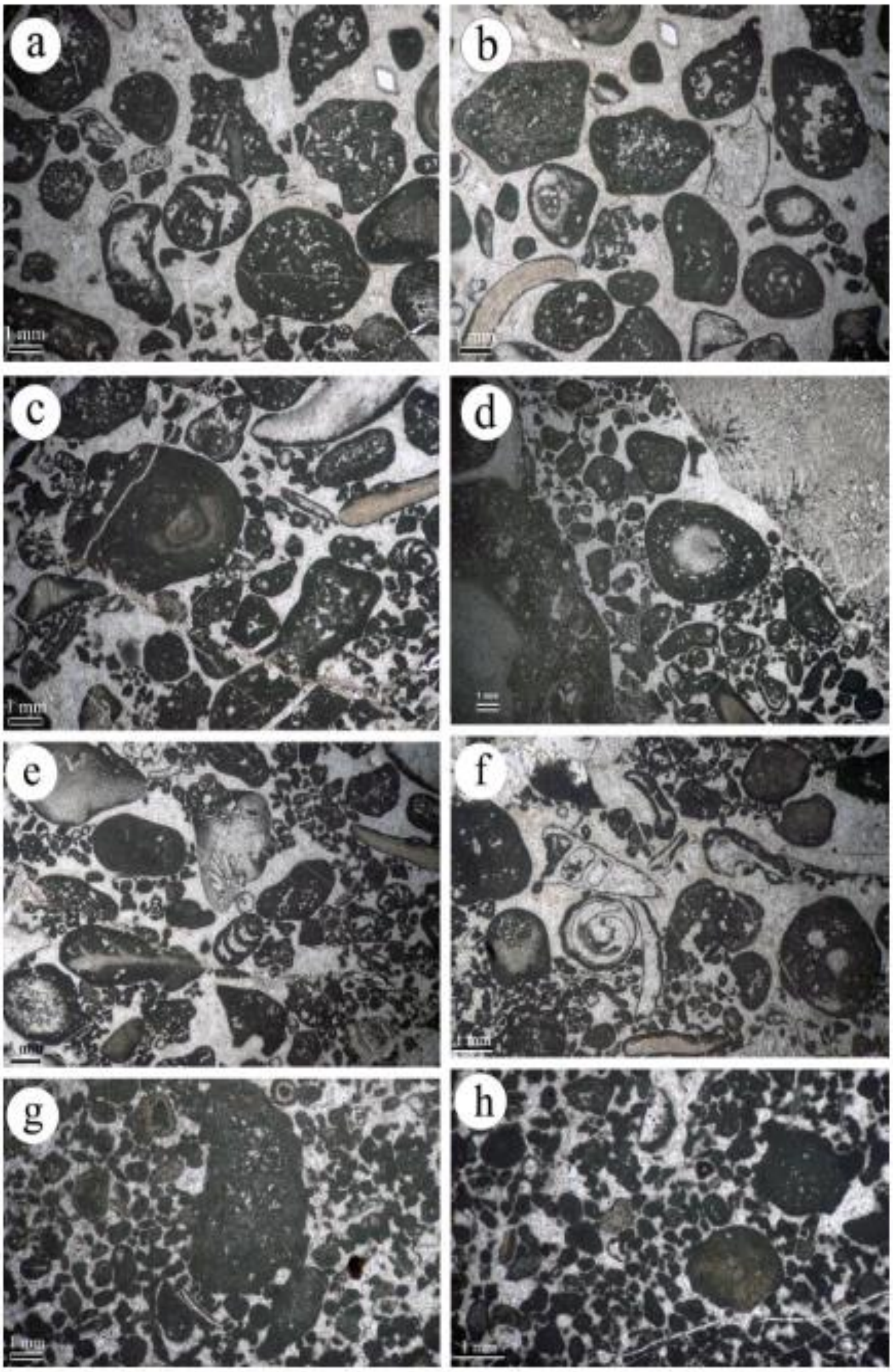

Fig. 27 – Intraclastic/bioclastic-dominated shoals. **a-f** Coarse intraclastic-bioclastic grainstone and rudstone containing intraclasts, oncoids, peloids, normal and incipient ooids. **g-h** Intraclastic-bioclastic grainstone and rudstone with vadoids. Bioclasts are represented by large benthic foraminifera (**a, c-d**), coral fragments (**b, d-e**), rivulariacean-type cyanobacteria (e.g. *Diversocalis* sp.) (**c**), bivalve fragments, echinoderm fragments, dasycladalean algae (*Clypeina sulcata* (Alth), (**a**) and gastropods (**f**); intraclasts and blackened bioclasts (black pebbles) (**a, c, d, f, h**) – from Săsăran et al. (2017).

Upstream the Dâmbovicioara Valley, the marlstones of the Dealul Sasului Member (late Valanginian-late Hauterivian in age), as well as of the Valea Muierii Member (late Hauterivian-early Aptian in age) are exposed. The calcareous nannofossils of this outcrop (Fig. 28) contain besides Lower Cretaceous other taxa, *Lithraphidites bollii.* This nannofossil firstly appears within the Lower Hauterivian, above the Valanginian-Hauterivian boundary at the GSSP of the Hauterivian stage (Mutterlose et al., 2021), while its extinction is situated within the Hauterivian/Barremian boundary interval (Perch-Nielsen, 1985; Mutterlose, 1991; Bown et al., 1998). The unit contains also Early Cretaceous macrofaunas (belemnites and ammonites, mostly fragments which are not very well preserved).

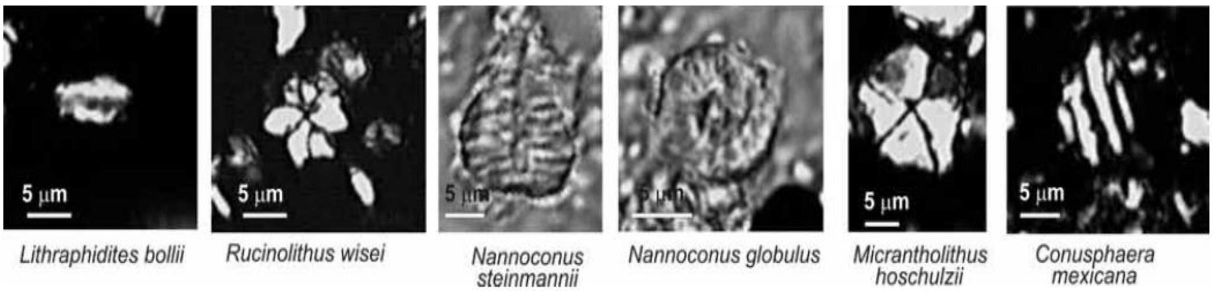

Fig. 28 – Hauterivian calcareous nannofossils identified in the Dealul Sasului Member of the Dâmbovicioara gorges.

STOP 8 – Urgonian klippe at Bran

The Bran Castle (Fig. 29) is a national monument and landmark in Romania. The fortress is situated on the border between Transylvania and Wallachia, being known as "Dracula's Castle" (although it is one among several locations linked to the Dracula legend, including Poienari Castle and Hunyad Castle). In 1212 the Teutonic Knights built the wooden castle of Dietrichstein as a fortified position in the Burzenland at the entrance to a mountain valley through which traders had travelled for more than a millennium, although it was destroyed in 1242 by the Mongols. The first documented testimony of Bran Castle is the act issued by Louis I of Hungary on November 19, 1377, giving the Saxons of Kronstadt (Braşov) the privilege to build the stone citadel on their own expense and labour force; the settlement of Bran began to develop nearby.

Fig. 29 – Aerial view of the Bran Castle.

The castle was firstly used in 1378 in defence against the Ottoman Empire, and later became a custom point for the mountain pass between Transylvania and Wallachia. The castle briefly belonged to Mircea the Elder of Wallachia, and later to his nephew, Vlad Ţepeş (Vlad the Impaler).

From 1920, the castle became a royal residence of the Kingdom of Romania. It was the principal residence of Queen Marie, and is decorated largely with artefacts from her time, including traditional furniture and tapestries that she collected to highlight Romanian crafts and skills. The castle was inherited by her daughter, Princess Ileana, and was later seized by the communist regime after the expulsion of the royal family in 1948. In 2005, the Romanian government passed a special law allowing restitution claims on properties such as Bran, which was seized by the Communist government of Romania in 1948. In 2006, the Romanian government awarded ownership to Archduke Dominic of Austria, Prince of Tuscany, known as Dominic von Habsburg, an architect in New York State and the son and heir of Princess Ileana, who had decided not to sell the castle, but instead turn it into a museum.

The Bran Castle from the Bran locality is placed on an impressive Urgonian allochtronous klippe (Fig. 30), made by limestones. These are placed in the upper Albian conglomerates and sanstones.

Around the Bran locality, there are several outcrops of Palaeogene successions. The Palaeogene sedimentation is represented by limestones with large foraminifers (nummulites) and by the bituminous rocks of the Oligocene Pucioasa-Fusaru Formation.

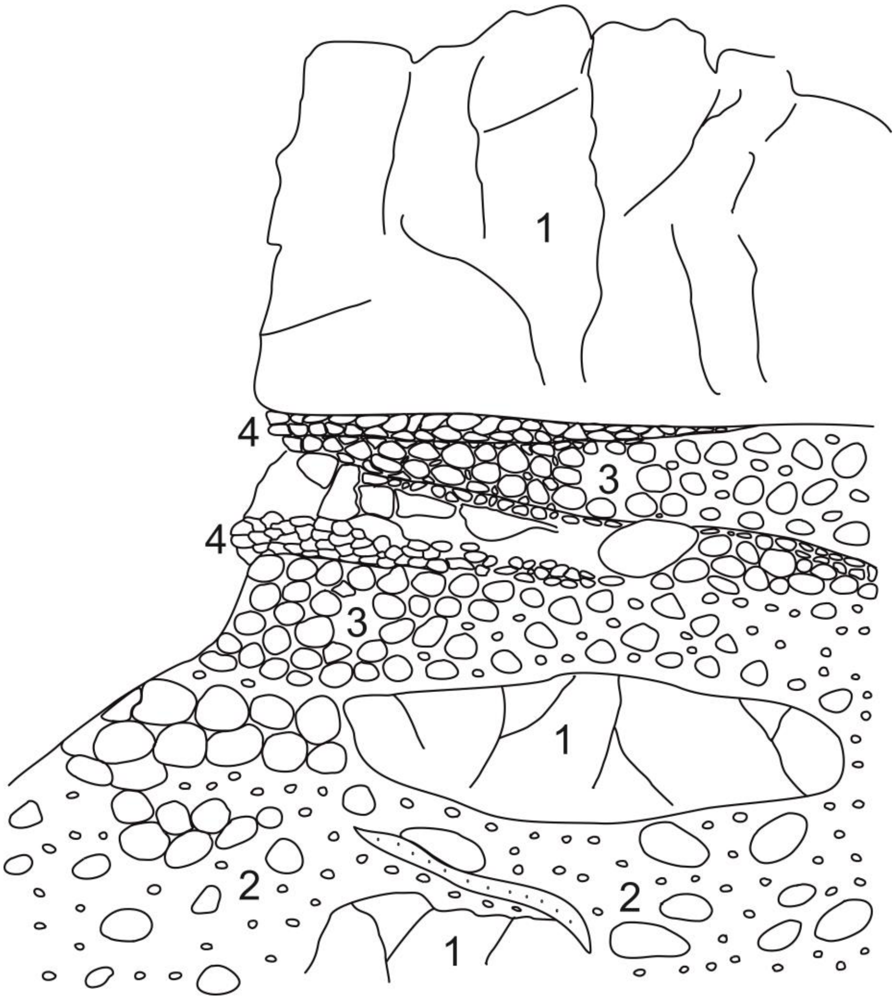

Fig. 30 – The Bran threshold calcareous breccias on the left flank of Valea Turcului, Bran locality. (redrawn after Patrulius, 1969). 1 - Urgonian massive white limestones; 2 - Chaotic polymictic conglomerates; 3 - Calcareous megabreccias and conglomerates; 4 - Calcareous microbreccias.

STOP 9 - Tithonian to Albian rocks in the Braşov Town

Braşov (Fig. 31) is the 7th largest city in Romania, surrounded by the Carpathian Mts., being located almost in the centre of Romania (176 km far from Bucharest). The city provides a mix of wonderful mountain scenery in the nearby Poiana Braşov (a well-known winter resort) and medieval history with German influences in the old town. Braşov is located at the foot of the Tâmpa Hill, consisting of Triassic, Jurassic and Cretaceous rocks that belong to the Getic Nappe of the Southern Carpathians and it is surrounded by a large depression (Ţara Bârsei), filled with Quaternary deposits.

Outcrops of Upper Jurassic-Lower Cretaceous (Tithonian to Barremian) limestones, Albian conglomerates and Lower Jurassic Gresten Formation that lies on the Triassic (Ladinian) limestones occur in abandoned quarries placed in the town. Most of the old monuments and houses (Fig. 31), dating from the 16^{th}-17^{th} Century, have been made by Cretaceous rocks, i.e., limestones and sandstones.

Fig. 31 – Downtown Braşov (the old City Hall is in the middle of the Council Square).

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