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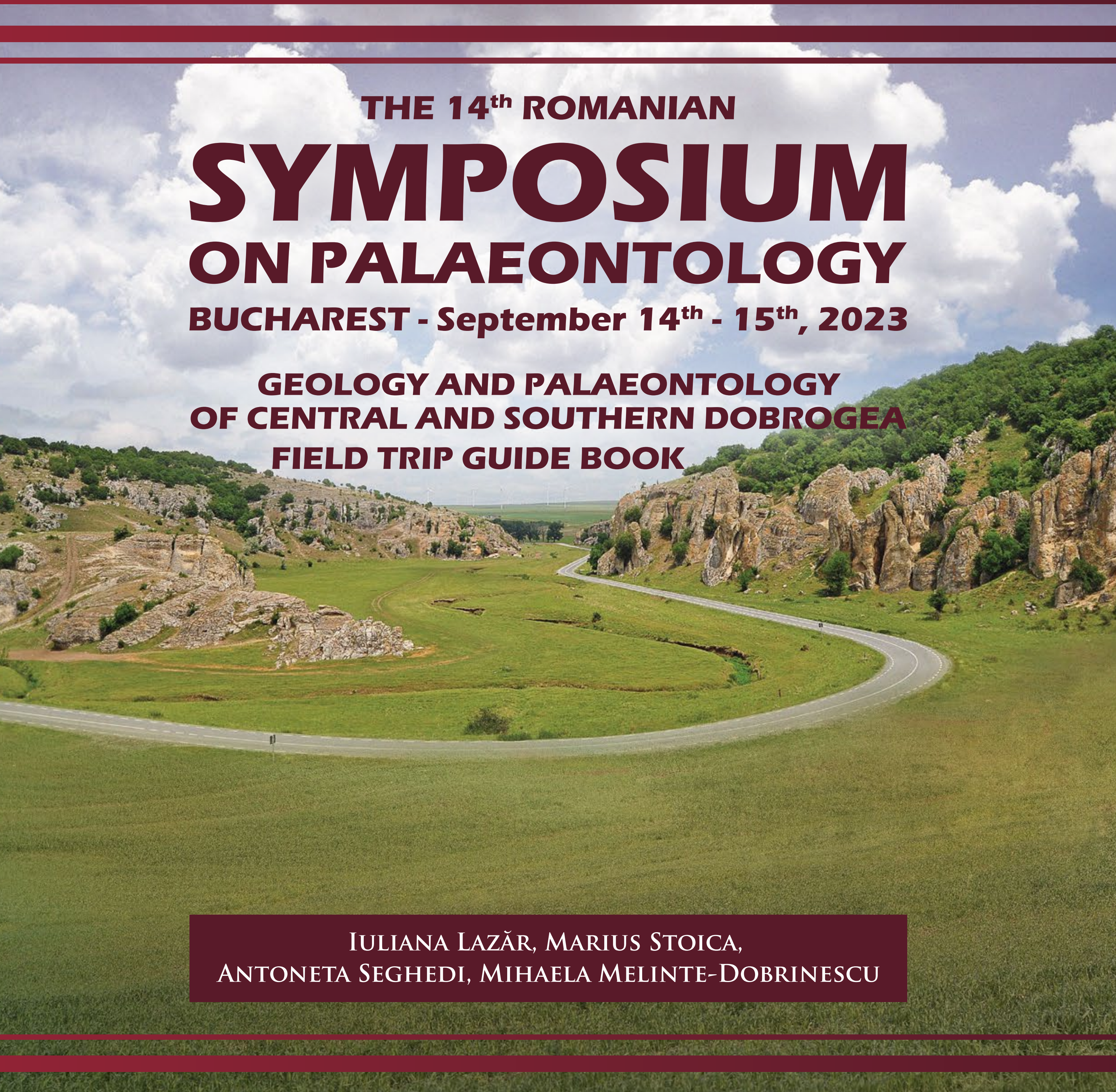

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GEOLOGY AND PALAEONTOLOGY OF CENTRAL AND SOUTHERN DOBROGEA
FIELD TRIP GUIDE BOOK

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ANTONETA SEGHEDI, MIHAELA MELINTE-DOBRINESCU

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OVERVIEW ON THE GEOLOGY AND PALEONTOLOGY OF CENTRAL AND SOUTHERN DOBROGEA

The Dobrogea territory is located in the south-eastern part of Romania, extending between the Black Sea shore to the east, and the Danube River to the north and west. It is a territory with a complex geological make-up represented by the North Dobrogea Orogen and the eastern part of the Moesian Platform (East Moesia).

The North Dobrogea Orogen is a Cimmerian fold-and-thrust belt with a Variscan folded and metamorphosed basement, covered by Triassic to Jurassic sedimentary and volcanic successions. The Cimmerian structures are sealed by Upper Cretaceous deposits accumulated in the post-tectonic Babadag Basin (Seghedi and Stoica, 2011).

The Moesian Platform is a major tectonic unit of the Carpathian and Balkan foreland, lying between the Carpathian Orogen to the north and west, the Balkanides Orogen to the south, and the western Black Sea basin to the east. The Moesian Platform is divided by the Intra-Moesian Fault into two units, East Moesia and West Moesia.

The field trip will explore the geology and paleontology of the territories of Central and Southern Dobrogea, which are parts of East Moesia.

The structure of the East Moesian Platform is affected by a system of WNW-ESE trending crustal faults: the Peceneaga - Camena Fault that separates the Central Dobrogea block from the North Dobrogea Orogen, and the Capidava - Ovidiu Fault that separates the uplifted Central Dobrogea block from the downfaulted South Dobrogea block. These faults represent important trans-crustal tectonic elements which extend northwest-ward across the Moesian Platform and under the Eastern Carpathians. To the south, the same faults extend to the territory of Bulgaria, as well as eastwards towards the Black Sea self. Westwards, there is an important geomorphological step between Dobrogea and the eastern part of the Romanian Plain due to a roughly N-S trending fault system along the Danube that is responsible for the uplift of the Southern Dobrogean compartment.

Central Dobrogea

The basement of Central Dobrogea

In Central Dobrogea **the basement** is represented by two terranes: the metamorphic rocks (metapelites and metabasites) of the Upper Proterozoic **Altîn Tepe Group** which are exposed in an antiformal fold south of the Peceneaga-Camena Fault, and the overlying

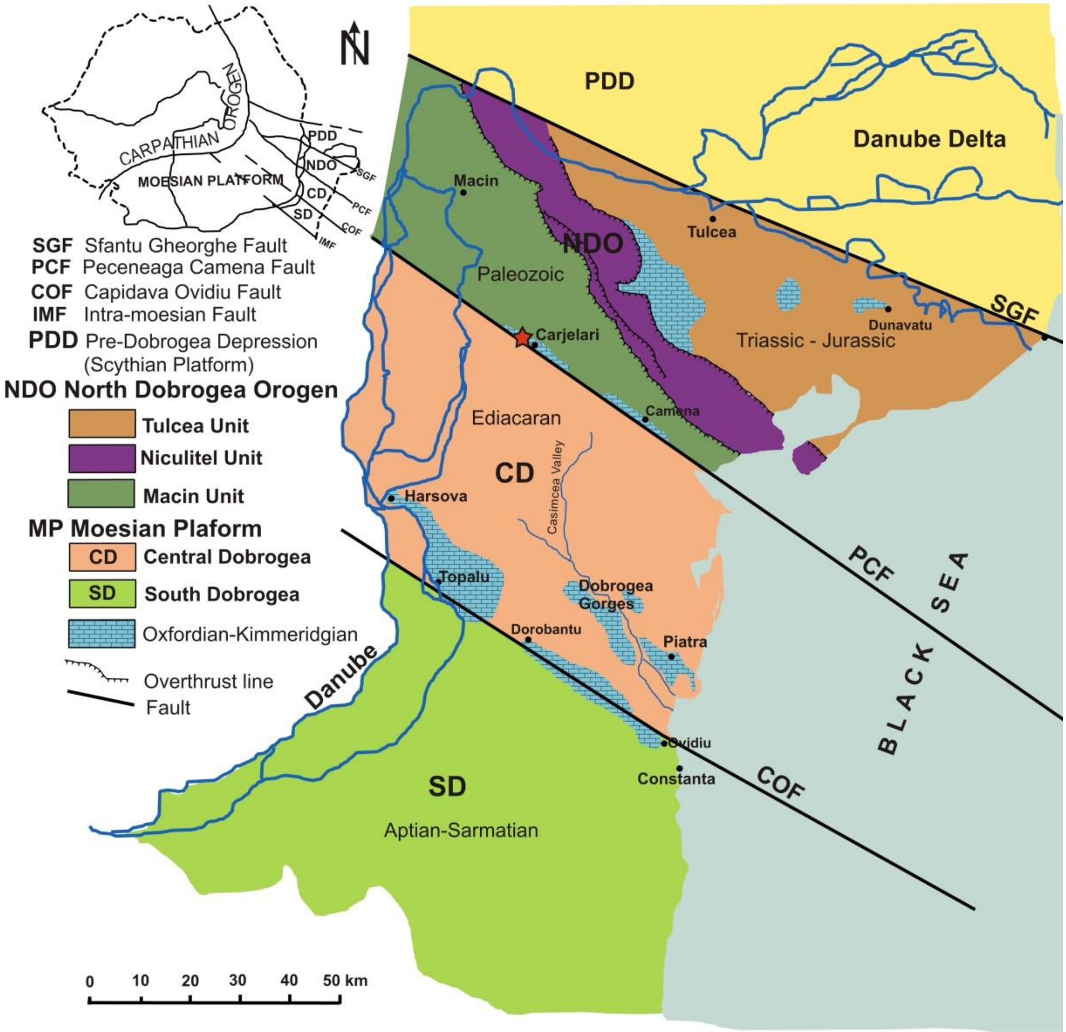

Fig. 1. Simplified geological map of Dobrogea
(modified from Seghedi, 1999) (the post-tectonic Babadag Basin is omitted).

Histria Formation (Upper Neoproterozoic- Ediacaran) (Oaie *et al*., 2005; Seghedi, 2012). The Central Dobrogea block exposes over large areas the Neoproterozoic Moesian basement represented by the Histria Formation, a thick (almost 5000 meters, cf. Mirăuţă, 1965, 1969) turbidite succession that is composed of three members: the lower Beidaud Member and the upper Sibioara Member are both coarse, sandstone-dominated, middle-fan turbidities, while the middle Haidar Member consists of fine-grained, distal fan – abyssal plain turbidites (Oaie *et al.*, 2005). The Late Neoproterozoic (Ediacaran) age of the Histria Formation was demonstrated by Oaie (1992, 1999, 2010) and Oaie *et al*. (2005, 2012) based on a scarce Ediacara-type fauna, as well as by detrital zircon ages (Żelaźniewicz *et al*., 2009; Balintoni *et al*., 2011).

The Histria Formation was affected by very low-grade metamorphism, sub-greenschist facies conditions, during the Late Neoproterozoic.

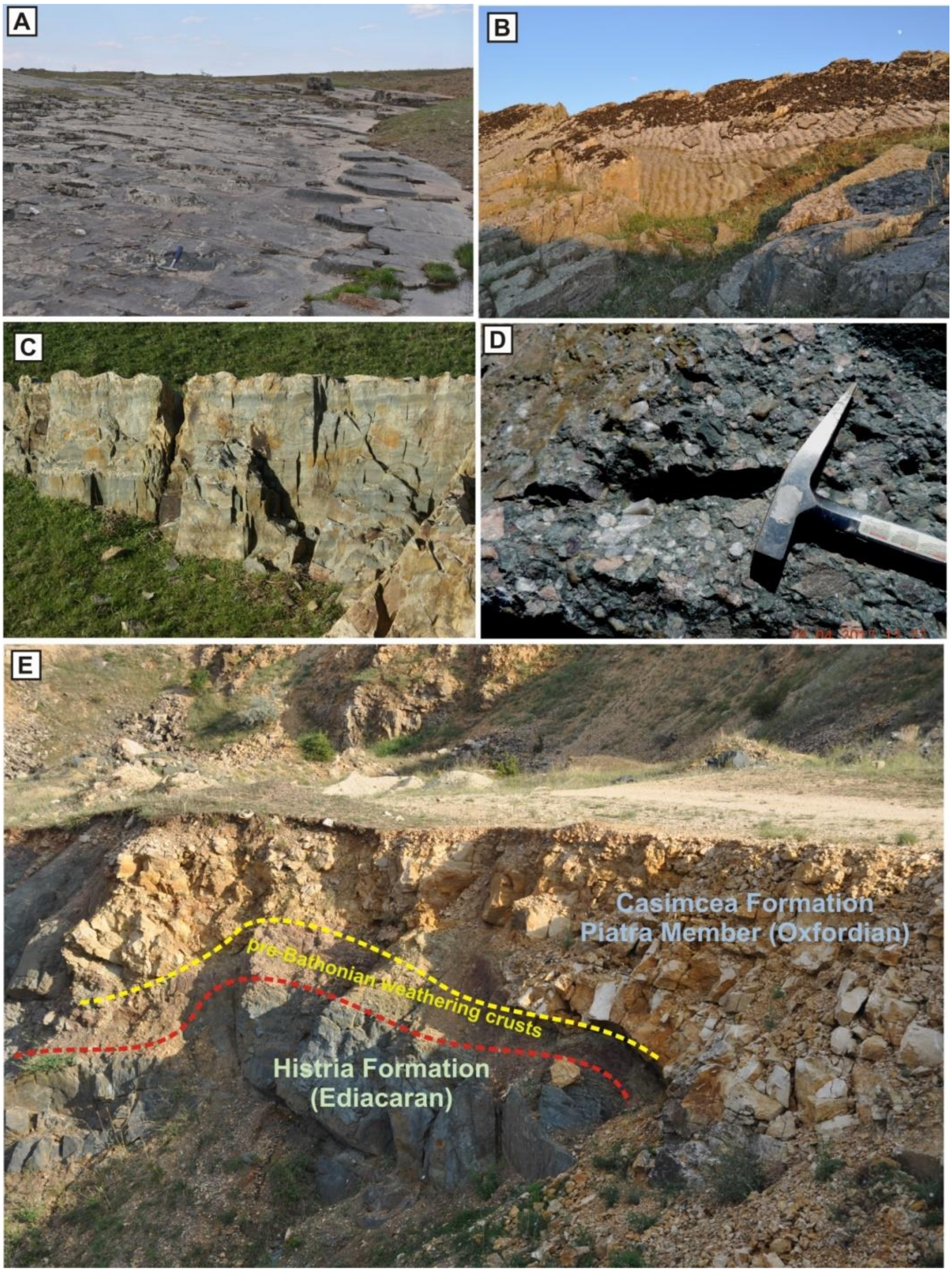

Fig. 2. A - Thin bedded distal turbidites, Histria Formation, Piatra; **B** - bedding surface with ripple marks parallel to the current direction on the bed surface of fine-grained turbidites, Haidar Member, Histria Formation; **C** - outcrop view of distal turbidites with Tcde Bouma divisions; **D-** coarse-grained conglomerate, Sibioara Member, Histria Formation; **E** – base of the Sîrtorman Quarry: topmost part of coarse-grained conglomerates of the Histria Formation covered by reddish pre-Bathonian weathering crusts supporting the Oxfordian limestones of the Casimcea Formation.

Locally, the turbidites of the Histria Formation are unconformably overlain by quartzitic sandstones with Ordovician graptolites (only in boreholes NW of the Danube) (Mirăuţă 1967; Iordan 1992, 1999) and by remnants of a pre-Bathonian palaeo-weathering crust (in outcrops) (Rădan, 1999). The marine sedimentation in Central Dobrogea resumes during the Middle Jurassic.

The Jurassic of Central Dobrogea

Starting with the **Middle Jurassic** (Bathonian) the sedimentary cover of Central Dobrogea is represented by mixed carbonate-terrigenous deposits with variable thickness (from 0 to 35 meters thick) due to the transgressive character of the sedimentation during the Bathonian, and to the reduced rate of sedimentation and to "*condensation*" processes during the late Bathonian – early Callovian. These deposits overlie the Histria Formation.

The lithostratigraphy and paleontology of the Middle Jurassic deposits were studied in detail by Bărbulescu (Bărbulescu, 1961a, 1961b, 1964, 1971, 1974) and Drăgănescu and Beauvais (1985), and paleoenvironmental reconstructions were performed by Bărbulescu (in Dragastan *et al*., 1988). The Middle Jurasic deposits are represented by two units:

- The Tichileşti Formation (Drăgănescu, 1985) (Bathonian-lower Callovian)
- The Gura Dobrogei Formation (Drăgănescu, 1976 (middle - upper Callovian).

The Tichileşti Formation (Bathonian-lower Callovian) shows a highly variable lithology with mixed terrigenous – carbonate successions (conglomerates, calcareous sandstones, calcarenites, silty marls, crinoidal limestines, and nodular limestones) developed as "*normal*" sedimentary sequences and "*condensed*" sedimentary sequences (cf. Drăgănescu, 1985). The "*normal*" sedimentary sequences (with thicknesses varying between 6 and 35 meters) are represented by several members with peculiar lithologies and containing specific marine faunas:

- Movila Mare – Dobriţa Member (conglomerates, quartzose sandstones, biocalcarenites). The biocalcarenites contain numerous bivalves (*Homomya, Ceratomya, Pholadomya)* along with ostreoids, solitary corals, crinoids, brachiopods, and benthic foraminifera.

- Mireasa Member (marly limestones) with abundant bivalves, nautiloids and ammonites (*Siemiradzkia matisconense, Holcophylloceras, Calliphylloceras, Phylloceras hatzegi).* A lagunar lithofacies, containing upper Bathonian small (one meter thick) coral-buildups, crop out in a small area in the upper part of Sîrtorman Valley. Beauvais (1985) described from this area solitary corals (*Chomatoseris, Thecocyathus, Cymosmilia*) and numerous colonial corals (*Isastrea limitata, Allocoeniopsis luciensis, Thamnoseris cadomenis, Dendrarea racemosa,Cymosmilia tenuicaulata).*

- Baroi Member (marly limestones, marls, biocalcarenites) with bivalves, brachiopods, crinoids and ammonites (*Macrocephalites macrocephalus*, *M. verus*, *M. compressus, M. gracilis*);

- Hârşova Member (biocalcarenites) with rare brachiopods, belemnites, ammonites, echonoids.

The *condensed*" sedimentary sequences of the Tichileşti Formation show reduced thickness (3-7 meters) and a mixed terrigenous-carbonate litology hosting parautochthonous assemblages with numerous bivalves, brachiopods and rare gastropods, echinoderms and corals.

The Gura Dobrogei Formation (middle - upper Callovian) consists of biocalcarenites with abundant crinoid ossicles, echinoid spines, rare bryozoans and fragments of bivalve shells.

The contact between the Middle Jurassic and Upper Jurassic formations can be observed in the Gălbiori and Celea Mică quarries.

During the **Late Jurassic** (Oxfordian-Kimmeridgian), an extended carbonate platform (the Moesian Carbonate Platform) occupied Central and Southern Dobrogea.The Moesian Carbonate Platform was a complex system of carbonate platforms/ramps developed on the European passive margin of the Northern Neotethys during the Late Jurassic–Early Cretaceous. The Moesian Carbonate Platform is well developed in Bulgaria, Serbia, and Romania (Patrulius *et a*l., 1976). The Upper Jurassic carbonate succession from Central Dobrogea represents the eastern part of the Moesian Carbonate Platform. During the Oxfordian–early Kimmeridgian interval a system of microbial-sponge and coral buildups developed in Central Dobrogea. These Oxfordian-Kimmeridgian carbonate deposits from Central Dobrogea are well known in the geological literature as part of the European Upper Jurassic sponge megafacies (sponge-microbial reefs) developed from Portugal, through Spain, France, southern Germany, Poland, Romania, Crimea to the Caucasus (Leinfelder *et al.*, 2002). The lithostratigraphy and biostratigraphy of these deposits in Central Dobrogea have been studied since the beginning of the 20th century by Simionescu (1907, 1910a, b). Detailed studies on the lithofacies, microfacies, paleontology, and sedimentology of these carbonate buildups were performed by: Bărbulescu (1971, 1974, 1976, 1979); Drăgănescu (1976); Roniewicz (1976); and Herrmann (1996).

This shallow-water carbonate succession was described as the **Casimcea Formation** (Drăgănescu, 1976) and it reveals a high complexity of lithofacies, being composed of eight members. These lithostratigraphic units display successive lateral and vertical replacements with a spatial and temporal distribution that indicate deposition on a gently westward deepening homoclinal ramp with E-W facies zonation.

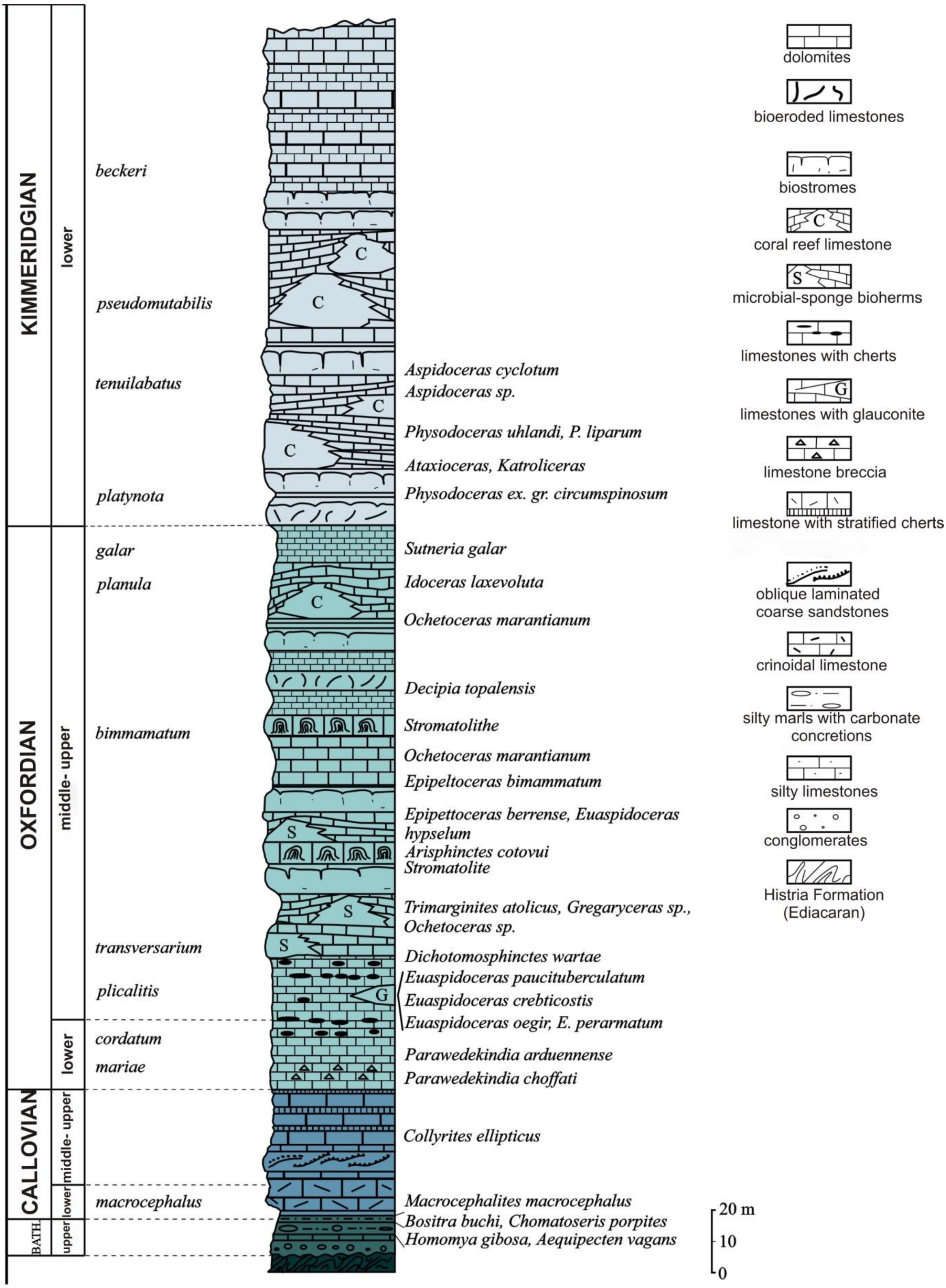

Fig. 3. Lithostratigraphic log of the Jurassic deposits from Central Dobrogea (modified from Bărbulescu, 1974).

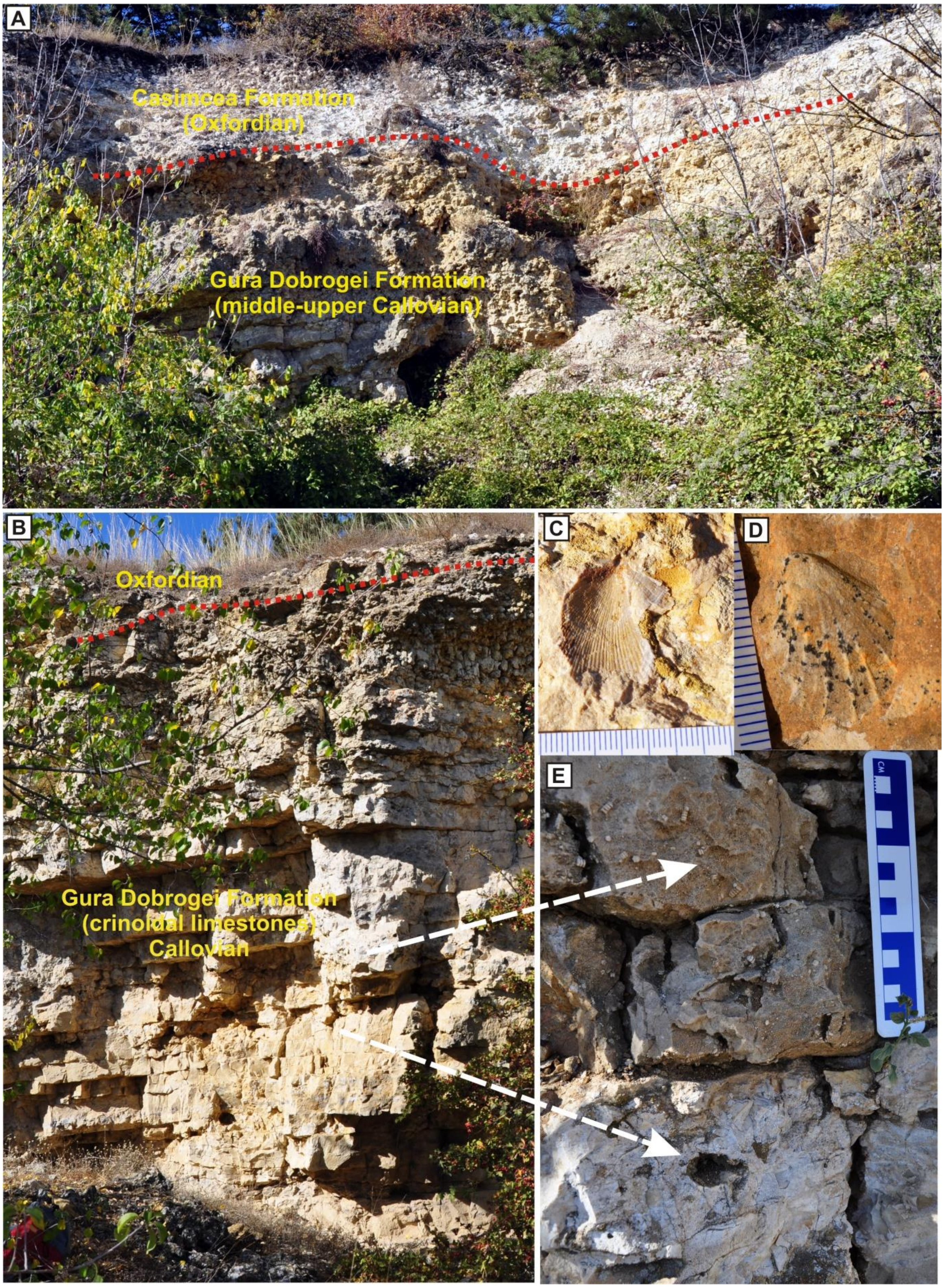

Fig. 4. Ghindăreşti Quarry **A, B**- Outcrop view of the contact between the Gura Dobrogei Formation (Callovian) and the Casimcea Formation (Oxfordian); **C**- *Chlamys textoria*, **D** - *Aequipecten vagans;* E- crinoidal limestones (Callovian).

Fig. 5. Celea Mică Quarry **A, B**- Outcrop view of the contact between the Gura Dobrogei Formation (middle-upper Callovian) and the Casimcea Formation, Visterna Member (lower Oxfordian); **C**, **D** – lower Oxfordian ammonites from microbial-sponge limestones.

The most significant members of the Casimcea Formation, with a wide development and distribution across Central Dobrogea are:

- **the Visterna Member (lower – upper Oxfordian)**: spectacular microbial-sponge ring-shaped bioherms and biostromes (for details see stop 13. Dobrogei Gorges – Casimcea syncline);
- **the Cechirgea Member (middle – upper Oxfordian)**: an impressive succession of laminated, mostly carbonate organo-sedimentary deposits (stromatolites and thrombolite mounds), that were described by Drăgănescu as microstromatolites and megastromatolites (in Patrulius *et al*., 1976). Drăgănescu (1976) recognized eleven successive stromatolitic levels (for details see stop 1. Cechirgea Valley-Veriga Chanel);

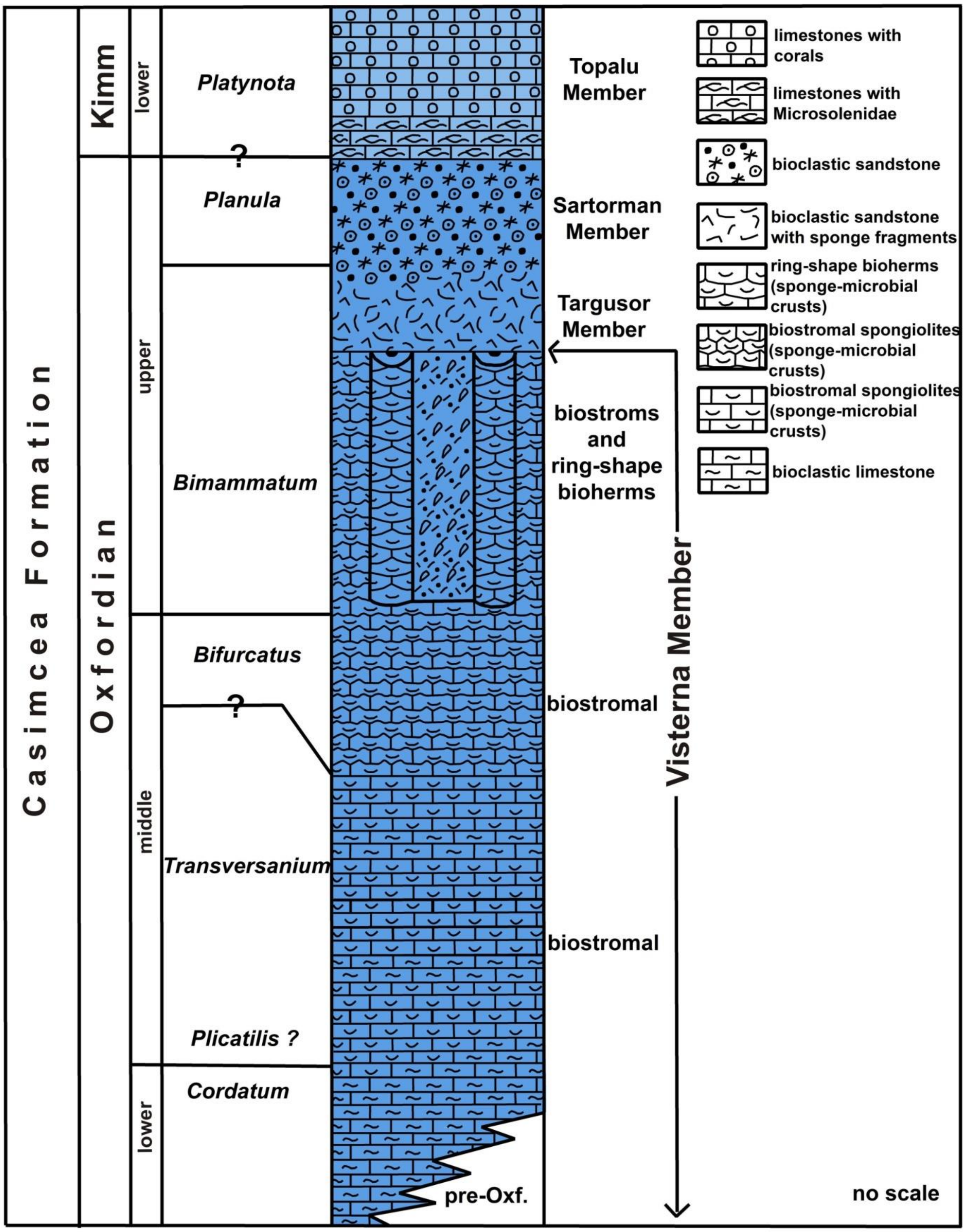

Fig. 6. Lithostratigraphic log of the Casimcea Formation (modifed from Bărbulescu in Dragastan *et al.*, 1998).

- **the Piatra Member (middle – upper Oxfordian)**: a thick (20-30 meters) coral limestone sequence represented by coral floatstone to coral framestone biostromes and bioclastic limestones (mollusk-coral floatstone/rudstone/bindstone and ooidal bioclastic grainstone/rudstone) (for details see stop 12. Piatra limestone Quarry)

- **the Topalu Member (uppermost Oxfordian – lower Kimmeridgian):** massive coral bioherms laterally linked into a continuous biostrome (almost 15-20 meters thick). More than 69 species of corals were described from this subunit by Roniewicz (1976), and the associated rich invertebrate fauna (bivalves, gastropods, brachiopods, bryozoans, echinoids, crinoids, rare ammonites) was studied by Bărbulescu (1974).

The first mention regarding the occurrence of fossil decapod crustaceans in Dobrogea belongs to Muţiu and Bădăluţă (1971), reported from drilling cores in Southern Dobrogea. During the last decades, more than 30 species of decapods have been described by Feldmann *et al.* (2006); Schweitzer *et al*. (2007); Franţescu (2010); Schweitzer *et al*. (2017, 2018); Franţescu *et al.* (2018) from the Upper Jurassic (Oxfordian-Kimmeridgian) carbonate deposits, mainly from Central and Southern Dobrogea. In these rich decapod asamblages a few new specieswere also reported, such as: *Cycloprosopon dobrogea* Feldmann, Lazăr and Schweitzer, 2006, *Goniodromites aliquantulus* Schweitzer, Feldmann and Lazăr, 2007, *Goniodromites narinosus* Franţescu, 2010, *Concavilateris barbulescuae* Franţescu, 2010, *Eodromites dobrogea* Feldmann, Lazăr and Schweitzer, 2006, *Laeviprosopon lazarae* Franţescu, 2010, *Abyssophthalmus marcistrix* Schweitzer *et al*., 2018, *Longodromites akainokkos* Schweitzer *et al*., 2018, and *Planoprosopon conspicuous* Schweitzer *et al*., 2018.

The Cretaceous of Central Dobrogea

In the southern part of Central Dobrogea, the Lower Cretaceous is represented by Aptian – lower Albian continental-lacustrine deposits that are similar to deposits recognized in Southern Dobrogea (**Gherghina Formation and Cochirleni Formation**); the Lowr Cretaceous covers directly the Histria Formation (Ediacaran) or else different units of the Jurassic. Small outcrops of Lower Cretaceous deposits can be observed near the following localities: Capidava, Vlad Ţepeş, Dorobanţu, Nicolae Bălcescu, Piatra, Hârşova, Ghindăreşti, Mihai Kogălniceanu, Valea Adâncă.

Albian sands and sandstones deposits were accumulated in the cavities of a palaeo-relief carved into Jurassic limestone (north of Topalu and Hârşova localities).

The Upper Cretaceous deposits from Central Dobrogea (Cenomanian, Turonian, Senonian) represent a prolongation of the same successions from the Babadag syncline.

Cenomanian-Turonian deposits starts with conglomerates followed by glauconitic calcareous sandstones. Outcrops can be observed near the Peceneaga-Camena fault, between Mihai Viteazu and Baia villages.

Senonian deposits (Santonian, Campanian and Maastrichtian) are represented by limestones with inoceramid faunas. Upper Cretaceous chalk also crops out in isolated locations and corresponds to the Murfatlar Formation from Southern Dobrogea.

Southern Dobrogea

The Basement of Southern Dobrogea

The Southern Dobrogea basement is not exposed, but it was reached in a few boreholes in the eastern part of this unit (Palazau, Cocoşu). The basement consists of Lower Precambrian (Archaean) kata / mesometamorphic rocks, represented by granitic gneisses with microcline, crossed by pegmatite veins (**the Ovidiu Group**, cf. Ionesi, 1994). Unconformable over this unit, a mesometamorphic quartzite-amphibolitic succession was recognized. These rocks contain (in their middle part) an iron oxide-rich level that suggests affinities with the Krivoi Rog Formation from the Ukrainian Massive. The age of this metamorphic unit - the **Palazu Group** - is considered as Middle Precambrian (the radiometric measurements indicate 1850-1670 Ma.) (Ionesi, 1994).

These kata / mesometamorphic series are covered by ankimetamorphic volcano – sedimentary deposits reprezenting the **Cocoşu Series** (Mirăuţă, 1965, 1969) or the **Cocoşu Group** (Ionesi, 1994). Radiometric K/Ar measurements indicate an age of 550 Ma for these rocks.

The sedimentary cover of Southern Dobrogea

The sedimentary cover in Southern Dobrogea reveals a sedimentary succession ranging from Cambrian to Pliocene, divided into several sedimentary cycles separated by gaps of variable time spans. The main sedimentary cycles are: Cambrian? – Carboniferous, Permian? - Triassic, Middle Jurassic- Upper Cretaceous, Eocene – Oligocene, Miocene – Pliocene. The spatial distribution of these sediments is not uniform all over Southern Dobrogea, being influenced by palaeogeography and tectonics.

Stratigraphy of the Paleozoic deposits of Southern Dobrogea

The Mangalia quartzite unit (Lower Cambrian?): these deposits reach 500 m in thickness and are represented by quartzites. Their age was estimated based on their palynological content and spatial relationships (Muţiu, 1991).

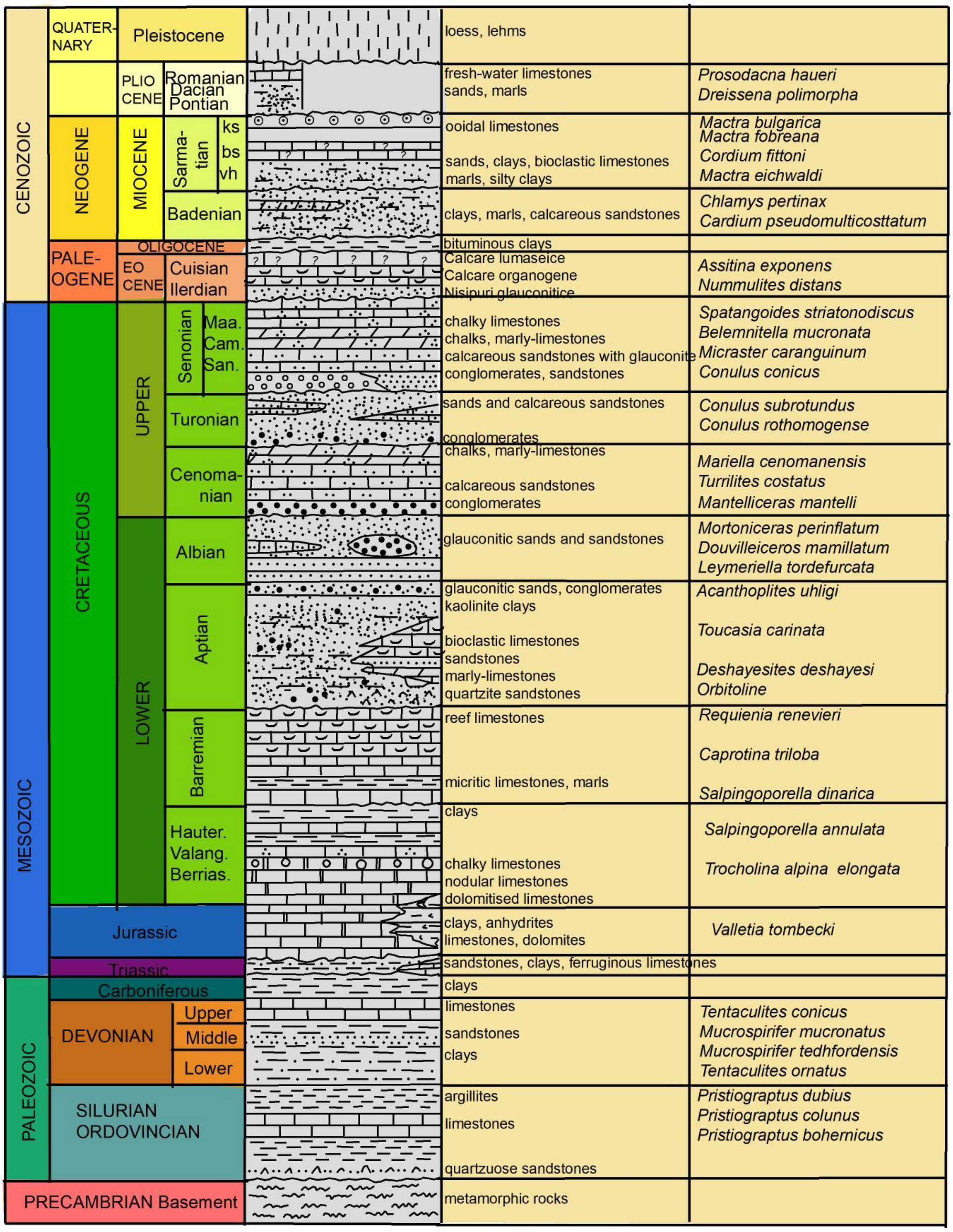

Fig. 7. Lithostratigraphic log of the sedimentary cover of Southern Dobrogea (modified from Mutihac and Mutihac, 2010).

The Ţăndărei argillites unit (Middle Cambrian – Lower Devonian) consists of black argillaceous shales interbedded with thin limestone beds. These deposits are rich in graptolites (*Pristiograptus bohemicus, P. colonus, P. dubius*), tentaculites, brachiopods, (*Asperopyge asiatica, Chonetes striatella, Spirifer infans*), nautiloids, bivalves, and trilobites. The thickness of this formation reaches up to 495 m.

The Smirna quartz sandstone unit (**Lower Devonian – Lower Givetian)** is represented by sandstones rich in quartz clasts, frequently with argillaceous shale intercalations. The fossil assemblages of these deposits are represented by tentaculites, brachiopods (*Mucrospirifer tedhfortensis*), gastropods (*Bellerophon sp.*), ostracods and conodonts. The thickness of this formation extends up to 650 m.

The Călăraşi Formation (Givetian – Lower Carboniferous, lower Visean): mainly carbonate deposits covering the Smirna Sandstone unit.

The Dobromiru Formation (middle – upper Visean): is represented by dark limestones interbedded with argillaceous shales, sandstones and siltstones. Brachiopods, bivalves, gastropods, nautiloids, bryozoans, echinoids, foraminifera and ostracods have been recorded from these deposits.

The Vlăsin Formation (Namurian – Westphalian): consists of dark argillaceous and sandy deposits with a few thin coal level intercalations. The thickness of these deposits extends up to 270 m.

Permian deposits have been also mentioned in South Dobrogea, but for the moment there are no definitive arguments to support their presence.

Stratigraphy of the Mesozoic deposits of Southern Dobrogea

Triassic - The Triassic deposits are represented by reddish to yellowish or dark sandstones, argillaceous shales, limestones, oolites, breccias and conglomerates. At some levels, lacustrine deposits with ostracods and charophytes could be recognized. The entire thickness of the Triassic sediments extends up to 100 m.

Jurassic - The Raşova Formation (Dragastan, 1985) (**Oxfordian – Tithonian)** is represented by a 500-600 m thick succession of limestones, with partial or complete dolomitization at some levels. Limestone breccias and marly intercalations are common. Dissolution processes affecting these carbonate rocks and increasing their porosity are characteristics of the deposits.

Upper Jurassic – Lower Cretaceous

The Amara Formation (Dragastan, 1985) **(Kimmerdgian – lower Berriasian)**: This formation includes lagunar / lacustrine deposits. In the lower part of the formation the evaporitic sediments (gypsum and anhydrite) are well developed (up to 200 m in thickness). This evaporite sequence is covered with green-reddish marls (40-60 m thickness) rich in lacustrine ostracods and charophytes, characteristic for the Purbeckian facies.

Lower Cretaceous

The Cernavodă Formation (Neagu & Dragastan, 1984) **(Berriasian – Valanginian – Hauterivian?)**: these are the oldest sediments cropping out in South Dobrogea. They can be observed on the right bank of the Danube, upstream of Cernavoda Bridge, as well as in many other places along the main streams connected with the Danube. The sediments are carbonates, represented by bioclastic limestone, oolites, marly-limstones intercalated with clays, microconglomerates with limestone clasts, and some breccia levels. The rocks are very rich in fossils, especially in foraminifera, ostracods, calcareous algae, sponges, corals, gastropods and bivalves. The thickness of this formation reaches 60-70 m (for details see stop 4. Cernavodă Bridge section).

The Ostrov Formation (Dragastan, 1985) **(Barremian – lower Aptian)**: This formation has a large outcropping area; it is developed in a carbonate facies, most common represented by bioacumulated limestones rich in pachyodont bivalve shells and orbitolinid foraminifera. Reef buildups are also present in this formation. The thickness of the deposits is estimated to about 100 m. Outcrops can be found in the Danube river bank between Cernavoda and Ostrov localities and also on the main Danube tributary rivers such as Carasu Valley. In one northern outcrop located near to Ovidiu locality, the Barremian deposits cover the Kimmeridgian succession. In the rest of Southern Dobrogea, the Barremian – lower Aptian rests on top of the Hauterivian deposits.

The Gherghina Formation (Avram *et al*., 1988) (**middle – upper Aptian)**: These deposits are developed only in the northern part of Southern Dobrogea, and are represented by red pebbles and conglomerates, sands, kaolinitic clays, and thin layers of coal, suggesting a continental / freshwater sedimentary environment. The thickness of this formation extends up to 60 m. During the middle – late Aptian almost the entire Southern Dobrogea was exposed and eroded, except for a few isolated areas (located today near to the Danube River) where small-scale marine-water invasions took place.

The Cochirleni Formation (Avram *et al.,* 1988) (**upper Aptian – Albian)**: The main characteristic of this formation is represented by the predominance of detrital sediments rich in authigenic glauconite. The fossil content is dominated by ammonites (*Hoplites*).

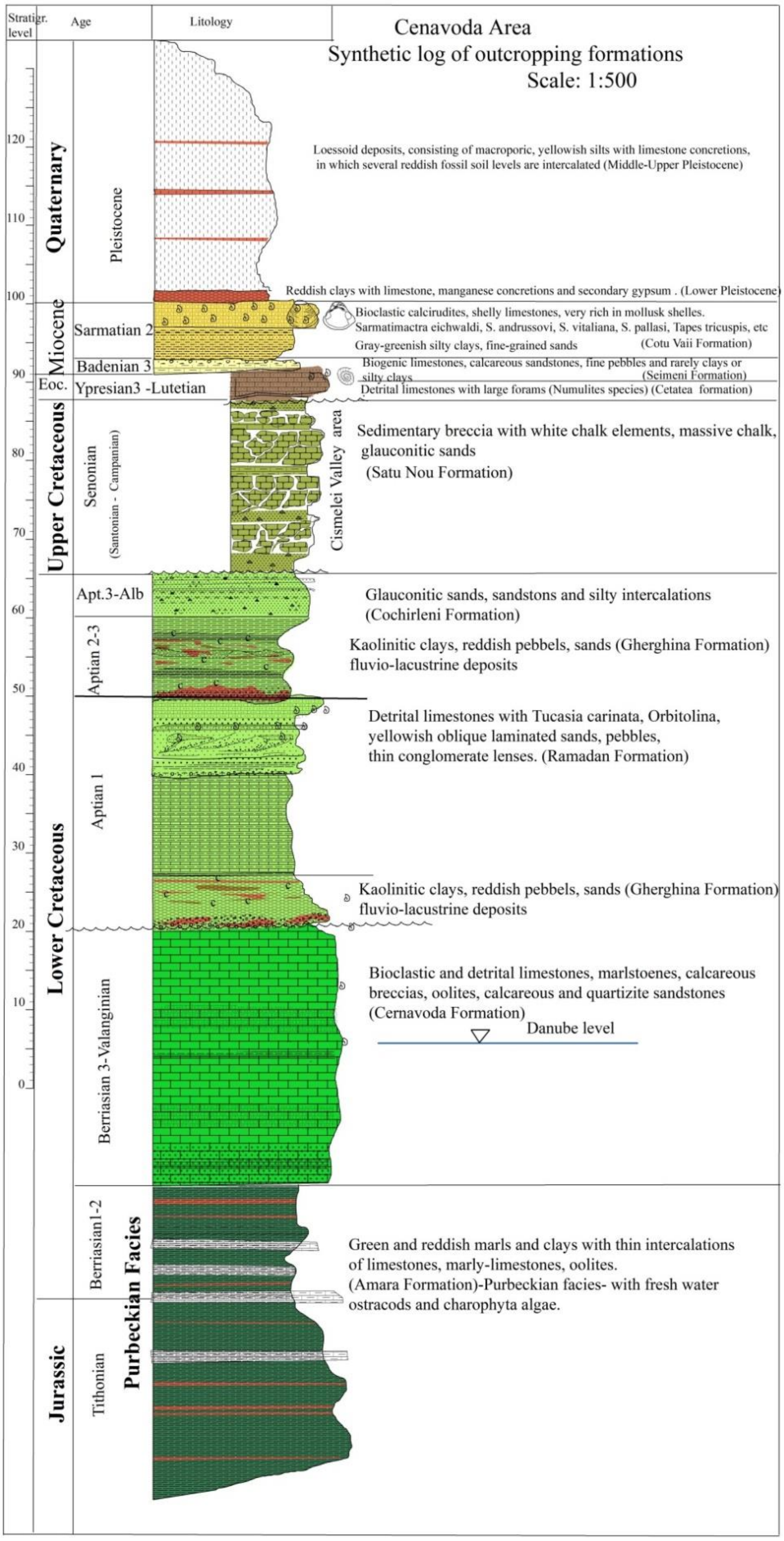

Fig. 8. Synthetic log of the Mesozoic and Cenozoic formations from the Cernavodă area (from Stoica, 2007).

The continental-lacustrine facies covers almost the entire area of Southern Dobrogea, except to the west of Carasu Valley where this formation can be found only in small patches that escaped from subsequent erosion.

The Peştera Formation (Avram *et al.*, 1988) (**Cenomanian)** and **the Dobromiru Formation** (Neagu and Dragastan, 1995-1996) (**Cenomanian)**: The Cenomanian transgression starts with conglomerates that pass into sandstones, silty-marls and glauconitic chalks. Foraminifera and ammonites dominate the fossil assemblages from these sediments. The thickness of the Cenomanian deposits is estimated to almost 50 meters (for details see stop 7. Petroşani Village, and stop 10. Peştera Quarry).

The Cuza Vodă Formation (Avram *et al.*, 1988) (**middle Turonian)**: This formation is almost 10 meters thick and lies unconformably (in both stratigraphic and sedimentologic discontinuity) on the top of the Peştera Formation. It is composed of basal conglomerates, followed be pebbles and sands, sandstones rich in echinoid and foraminifera assemblages, biomicrits with sponge fragments, radiolarians and cherts, and rare intercalations of marls (for details see stop 10. La Porcărie section). The Turonian deposits mark the transition from the mixed siliciclastic-carbonate sedimentation existing during the Albian-Cenomanian time interval, to a predominantly carbonate sedimentation during the Senonian.

The Murfatlar Formation (Avram *et al.*, 1988) and **the Satu Nou Formation** (Neagu and Dragastan, 1995-1996) **(Santonian – Campanian)**: these formations are mainly composed of white chalk (40 meters thick), with conglomerates and sandstones in the lower part of the succession. Chert nodules are common in the lower part of the chalk deposits. The fossil assemblage is dominated by planktonic foraminifera, sponges, belemnites and echinoids (for details see stop 5. Murfatlar Quarry).

Stratigraphy of Cenozoic deposits in Southern Dobrogea

Paleogene

The first Paleogene sequence in Southern Dobrogea starts with Eocene deposits. Three lithostratigraphic units were separated (Bombiţă, 1987):

The Văleni Formation (Avram *et al.*, 1997) **(lower Ypresian)**, represented mainly by siliciclastic, glauconitic sands with thin sandstone intercalations. The microfauna is dominated by large foraminifera (*Nummulites globules, N. pernotus* and *N. planulatus*) that support the early Ypresian age of this unit. This formation can reach up to 80 meters in thickness, and its spatial distribution is restricted to the southern sector of the Şipote – Cobadin - Eforie localities area (south-eastern extremity of Dobrogea).

The Lespezi Formation (Avram and Neagu, 1996) **(upper Ypresian)** is made up of sandy biocalcarenites (almost 10 meters thick, with a quartz-detrital content that represents 35-40%), containing a rich assemblage of large foraminifera (*Nummulites rotular, N. irregularis, N. pratii, N. distans*) and echinoids. This formation crops out in the Lespezi quarry and around Lespezi village; its age was considered as late Ypresian by Bombiţă (1964, 1987). However, Tătărâm *et al*. (1977) suggest an early Lutetian age for this formation (for details see stop 9. Lespezi Quarry).

The Cetate Formation (Avram and Neagu, 1996) **(Ypresian)** represents the lithostratigraphic unit with the largest areal distribution in the Southern Dobrogea, extending from the Cernavodă area (Ceşmelei Valley) and Ovidiu locality to the seaside between Constanţa-Tuzla and Enişenlia-Lespezi-Ceairu area, and Dobromiru Valley. The 20-25 meters thick Cetate Formation consists of light, soft biocalcarenites with variable siliciclastic content, and hosts a rich fossil assemblage of large foramimifera, echinoids and brachiopods. The foraminiferal assemblage is typical for the late Ypresian (Bombiţă, 1987), with *N. rotularis*, *N. distans, N. irregularis*, *N. pratti*, *N. archiaci*, *N. polygyratus*, associated with *Assilina placentula, A. laxispira, A. major* and *Operculina sp.* However, Tătărâm *et al*. (1977) considered a Lutetian age for this formation.

Oligocene

There are no outcrops of Oligocene deposits in Southern Dobrogea, but in few boreholes south of Mangalia locality, dark argillaceous shales and dissodilic shales (Maikop facies) were intercepted and these are considered to belong to this stage.

Neogene

The Neogene deposits from South Dobrogea crop out southwards of the Capidava-Ovidiu Fault. They belong to the Middle and the Upper Miocene, as well as to the Pliocene (Andreescu *et al.*, 1996), and unconformably overlay the Cretaceous-Paleogene formations. Two sedimentary cycles were separated: the Middle-Upper Miocene Cycle and the Pliocene Cycle. Each of these is represented by two subcycles separated by hiatuses.

Miocene

The Seimeni Formation (Andreescu, in Ghenea *et al*., 1984) (**Badenian, Konkian)**:
The Middle Miocene (Konkian) marine transgression covered almost the entire South Dobrogea area, although the deposits are outcropping only patchily. Gentle subsidence, a flat paleo-relief and shallow marine epicontinental waters have controlled the Konkian depositional environments. As a result, the Konkian deposits are represented mainly by biogenic limestones, calcarenites, calcareous sandstones, conglomerates, fine pebbles, and rarely clays or silty clays (0 to 6 meters thick) (Andreescu *et al.*, 1996).

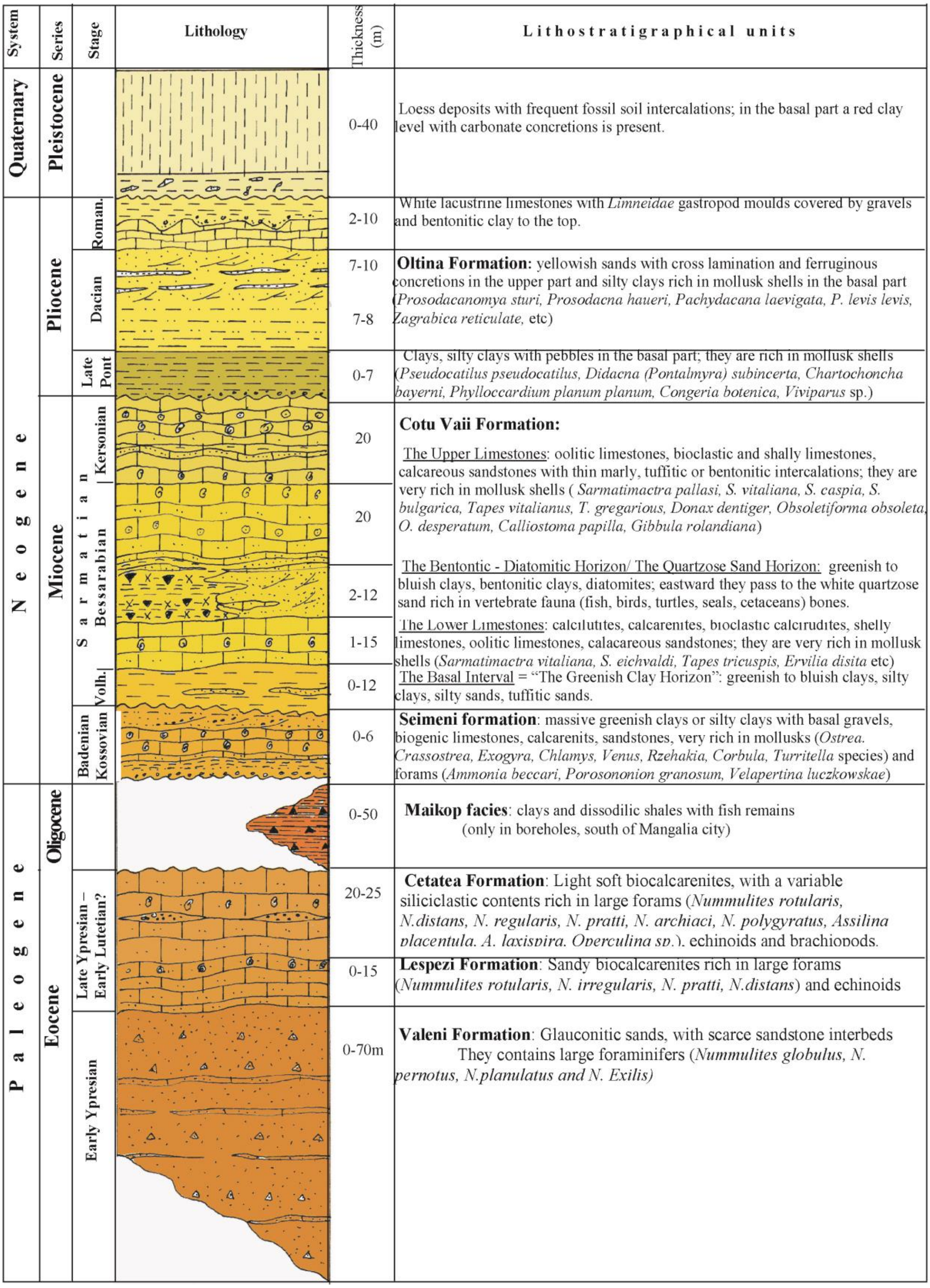

Fig. 9. Lithostratigraphic log of the Cenozoic deposits of Southern Dobrogea (from Dinu and Stoica, 2014).

The greenish clays or silty clays occur only in the basal part of the Konkian succession (“*argillaceous horizon*” cf. Chiriac, 1970). Sometimes a coarse detrital level occurs in the basal part of this argillaceous horizon. The clays are covered by carbonate rocks (“*calcareous horizon*” cf. Chiriac, 1970) that are very rich in mollusk shells and foraminifera. In the south–eastern part of South Dobrogea, this level is represented by soft conglomerates and fine gravels (3 meters thick) rich in Ostreidae bivalves (Canaraua Fetii section). In the Valeni section, calcareous sandstones, sands and pebbles are dominant. They contain *Congeria sandbergeri sandbergeri, C. sandbergeri buglovensis*, *Corbula gibba, Lucina michelotti, L. columbella, Loripes duhjardini, Venus marginatus, Turritella subangulata, T. depressocarinata, Venus sp.*, and *Crassostrea sp.* The foraminifera are represented by *Ammonia beccarii, Porosononion granosum, Pararotalia spinimargo*. In the north-western part of South Dobrogea, the marine Middle Miocene (Konkian) deposits are represented by calcareous sandstones and calcareous conglomerates with *Ostrea*, *Crasosostrea*, *Cubitostrea*, *Flemingostrea*, *Sacostrea*, *Exogyra*, *Amphidonte* and *Chlamys*.

The Middle Miocene marine deposits were assigned alternatively to the Burdigalian (Macovei, 1912), the Tortonian (Tchokrakian)(Chiriac, 1970; Ionesi and Ionesi, 1973), the upper Badenian (Ionesi and Chintăuan, 1976), or to the Karpatian (Rado and Pană, 1975; Tătărâm *et al*., 1977). The presence of the species *Velapertina luczkowskae* above the oyster-bearing detrital limestones from Seimenii Mari section proves the Konkian age of these deposits (Popescu in Andreescu et al., 1996).

The Cotu Văii Formation (Andreescu, in Ghenea *et. al*., 1978) **(Sarmatian, upper Volhynian – Kersonian)**: The Sarmatian deposits are well represented in Southern Dobrogea forming a quasi-continuous succession that covers the older formations. The Cotu Văii Formation consists of clay, bentonitic clays, diatomites, sands and consistent levels of bioclastic limestones and calcarenites rich in mollusk shells (especially *Mactra* species).

Four lithostratigraphical units were described for the Sarmatian sequence. Their vertical and horizontal distribution is variable according with different authors.

Andreescu (in Avram *et al*., 1990; Andreescu *et al*., 1996), separated the following lithostratigraphic units that could be considered either members of the Cotu Văii Formation or independent formations:

1. The basal unit (lower Volhynian) partly corresponds to the “*Greenish Clay Horizon*” of Chiriac (1960), and consists of grey, greenish to bluish silty clays, as well as silty and tuffitic sands. In the lower part of the sequence, rare, reworked angular Cretaceous elements occur. The thickness of this unit varies from 0.5 to 7.0 meters.

2. The clays and diatomites unit (Volhynian-lower Bessarabian): this unit is considered an equivalent of the “*Lower Limestones Horizon*” of Chiriac (1960), and it includes the bulk of the “*Diatomitic-Bentonitic Horizon*” of Chiriac (1960). This unit is composed of massive, greenish or bluish clays, gray-greenish to brown-blackish bentonitic

clays, thin bedded to massive diatomites, thin bedded or lenticular fine siliceous and calcareous sands, laminated marls, and whitish micritic limestones. The diatomites (2-3 meters thick) occur frequently in the upper part of the succession (Urluia, Adâncata, Nastradin, Şipotele), or else they are interbedded with bentonitic clays or limestones (Cetatea, Lespezi, Valea Rea, Negureni, Rariştea, Dobromiru, Ion Corvin). The maximum thickness (6-8 meters) of diatomites and bentonites is recorded along the north- south Adâncata-Urluia-Valea Rea-Cetatea alignment.

3. The Lower Limestones unit (Bessarabian) is represented by carbonate rocks, calcilutites, calcarenites, bioclastic calcirudites, shelly limestones, ooidal limestones, and calcareous sands. Qaurtzose sands, clays, silty clays, bentonites and diatomites are often interbedded with the carbonate rocks. The limestones are grey, whitish or white-yellowish, and the very thinly laminated clays are grey or brown. The calcareous succession is medium bedded, and sometimes the thicker beds are separated by discontinuities. In the Negureni area, a pile of 10 to 20 meters of quartzose white sands lie at the base of the limestone sequence. The fine to coarse sands with gravel lenses are cross-bedded and overlie the greenish bentonititic clays. The thickness of the Lower Limestones unit is variable (1 to 15 meters thick) and the associated fossil assemblage is very rich in mollusk shells (*Sarmatimactra eichwaldi, S. andrussovi, S. vitaliana, S. pallasi, Tapes tricuspis, T. vitalianus, T. navicualtus, Ervilia dissita, Obsoletiforma obsolete, Plicatiforma plicta, P. fittoni, Musculus naviculoides, M. sarmaticus, Donax dentiger, Solen subfragilis, Calliostoma sp., Duplicatata duplicate, D. corbiana, D. dissita, Pirenella disjuncta*) (for details see stop 7. Petroşani Village).

4. The Upper Limestones unit (upper Bessarabian-Kersonian) groups the uppermost sequences of the Sarmatian deposits from South Dobrogea. This unit unconformably overlies either the Lower Limestones unit, the lower part of bentonitic and diatomitic clays unit, or else the Konkian and Cretaceous deposits. This unit consists of carbonate rocks, ooidal and dolomitic limestones, calcarenites with *Nubecularia*, bioclastic limestones, calcareous sandstones, frequently separated by sandy, tuffitic intercalations or sandstones, bentonitic clays, marls, silty clays and siltstones. The thickness of the unit varies from 2 to 30 meters. One of the most characteristic features is the presence, in its lower part, of cross-bedded calcarenites, sandy limestones, calcareous sandstones or quartzose sands. The sands reach a consistent thickness of 10 to 15 meters along two alignments: one is located in the eastern part (east of Negreşti-Curcani-Independenţa localities), the other in the central-western sector (Ioan Corvin-Băneasa-Negureni). Chiriac (1960), Tătărâm *et al*. (1977) and Grigorescu and Dinu (1978) all considered the quartzose sands from the eastern alignment partially representing an equivalent of the "*Diatomitic-Bentonitic Horizon*". Grigorescu (1976) described a rich vertebrate fauna (fish, birds, turtles, seals, cetaceans) from these deposits (Credinţa Quarry). The sands of the western alignment (10-12 meters thick) overlie the Lower Limestones unit and underlie the Upper Limestones unit (Andreescu *et al*., 1996).

Another feature of the Upper Limestones unit consists in the frequent intercalations of red to reddish-brown residual clays and silts.

This unit is also very rich in mollusk shells, most of them with a poor state of preservation (*Sarmatimactra pallasi, S. vitaliana, Podolimactra podolica, Tapes vitalianus, T. gregarious, T. ponderosus, Donax dentiger, Plicatiforma fittoni, Barbotella sp., Calliostoma papilla, Gibulla rolandiana, Duplicatula duplicate, Litorina bessarabica,* etc.) that indicate their late Bessarabian age. The uppermost interval of the Upper Limestones unit is rich in *Sarmatimactra caspia, S. balcica* and *S. bulgarica*, an association which indicates a Kersonian (late Sarmatian) age.

Pliocene

Pliocene deposits crop out only in the westernmost part of South Dobrogea, especially along the right bank of the Danube and its tributaries, on a distance of about 70 km, between Ostrov and Cochirleni localities. The Pliocene realm has been located north-north-westwards of an indented escarpment, along which the Sarmatian deposits, if accumulated, were completely removed during the late Sarmatian-middle Pontian time interval (Andreescu and Pană, 1996). In these areas, the Pliocene deposits overlie the Cretaceous ones, and are covered by red clays (lower Pleistocene) or else by loess and loessoid deposits (middle and upper Pleistocene). The Pliocene deposits accumulated during the second Neogene cycle, when two short transgressive events took place in south-western Dobrogea,: the results of the first one represent the upper Pontian subcycle, and those of the second one, the Dacian-Romanian subcycle.

The thickness of the Pliocene deposits does not exceed 30 meters. They are represented by clays, marls, sands and thin sandstone beds, lacustrine limestones, and pebbles (in the top), rich in brackish - freshwater mollusks and ostracods.

Upper Pontian (Bosphorian): the upper Pontian sequence is 7 meters thick and consists of fine-grained sediments represented by clays, silty clays, marls with few intercalations of sands or pebbles. At some levels the sediments are very rich in mollusks (*Pseudocatillus pseudocatillus, Didacna (Pontalmyra) subincerta, Phylocardium palnum planum, Chartoconcha bayerni, Congeria botenica, Viviparus sp.*) and ostracods.

Oltina Formation (Andreescu în Pop *et al.*, 1991) **(Dacian)** consists of pebbles, sands, silty clays, deposits that are rich in mollusk shells (*Horiodacna rumana, Prosodacnomya stenopleura, P. sturi, Prosodacna haueri, P. munieri, Dacicardium sp., Pachydacna laevigata, P. levis levis, Zagrabica reticulate, Zamphiridacanacucestiensis, Z. orientalis, Melanopsis sp., Bulimus sp., Hydrobia grandis, Lithoglyphus acutus, Rumanunio rumanus, Viviparus duboisi*) especially in their lower part.

Fig. 10. Oltina Lake shore, upper Pontian silty clays and marls overlying Lower Cretaceous (Barremian) deposits (from Dinu and Stoica, 2014).

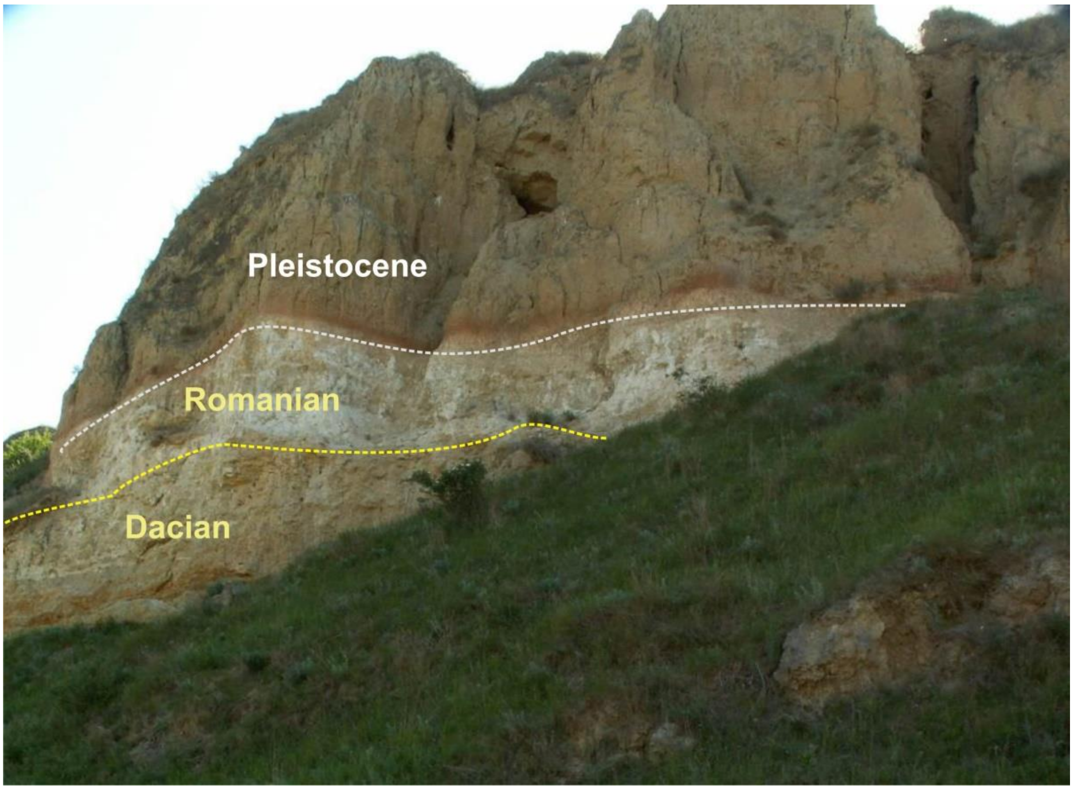

Fig. 11. Dunăreni (Mărleanu) Lake shore: outcrop view of the Dacian, Romanian, Pleistocene succession (modified from Dinu and Stoica, 2014).

Sedimentological features and faunal records indicate that these sediments were deposited in a transgressive delta environment, where reworked delta front sands became beach ridges and sand bars containing abundant parautochthonous shells (Andreescu and Pană in Avram et al., 1996). In the upper part of the Dacian sequence, yellowish ferruginous sands with sandstone lenses and concretions, as well as pebbles with cross-lamination, become more frequent.

Romanian: The Romanian deposits consist of lacustrine carbonates (limestones, calcarenites, sandy limestones, calcareous sands) with algae and moulds of freshwater or continental gastropods. Pană and Kruck (1972), Tătărâm *et al*. (1977) considered this succession as upper Dacian. The upper part of the Romanian deposits consists of non-fossiliferus silts, sands, pebbles accumulated in alluvial to fluvial environments.

Quaternary: the Quaternary succession covers most of the Southern Dobrogea surface. These deposits start with a reddish argillaceous level (lower Pleistocene), covered by up to 40 meters of loess deposits (middle – upper Pleistocene). Along the main streams, recent alluvial sediments are present.

DESCRIPTION OF STOPS

Fig. 12. Field trip itinerary in Central and Southern Dobrogea. Background – the geological map of Romania, scale 1:000.000 (Săndulescu *et al.*, 1978), Geological Institute of Romania.

First day: 16 September 2023

Stop 1. Cechirgea Valley - Veriga Chanel (Tichileşti-Topalu)

Iuliana Lazăr

Stratigraphy: Casimcea Formation: uppermost part of the Visterna Member (middle Oxfordian), Cechirgea Member (middle-upper Oxfordian), and lower part of the Topalu Member (uppermost Oxfordian-lowermost Kimmeridgian)

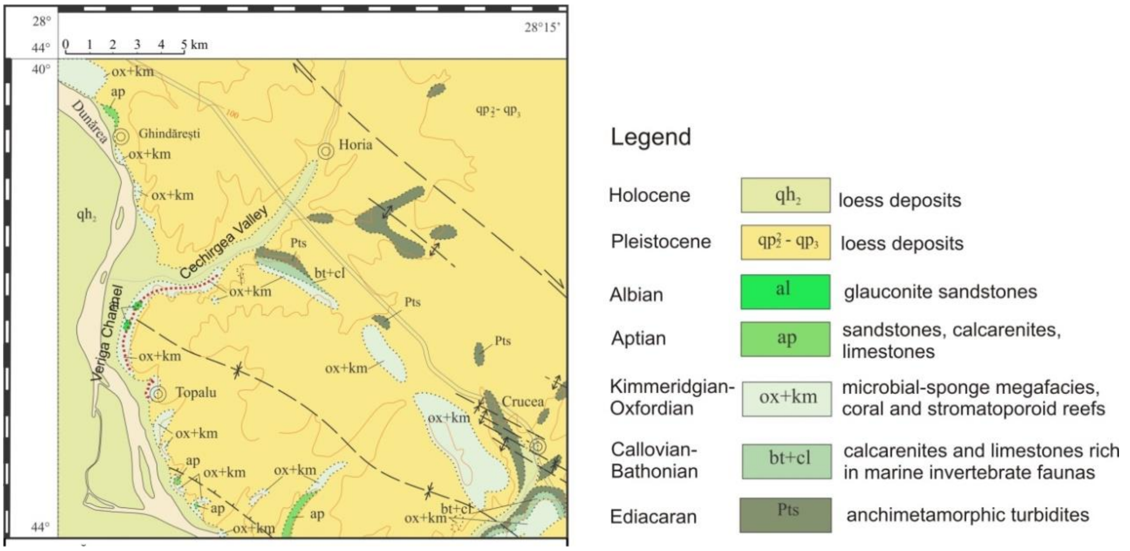

Fig. 1.1. Location of the outcrops along the Cechirgea Valley and Veriga Channel (red dotted line) on the geological outline map of the Topalu area (based on Chiriac et al., 1968).

Location: the profile consists of an approximatively 5 km long string of almost continuous outcrops, remains of former limestone quarries; these outcrops occur along the Cechirgea Valley (a right-side tributary of the Danube) (44°35'15.00"N; 28° 3'37.24"E) and can be followed along the Veriga Channel (an artificial channel on the right side of the Danube) to Topalu locality (44°34'4.58"N; 28° 2'2.59"E).

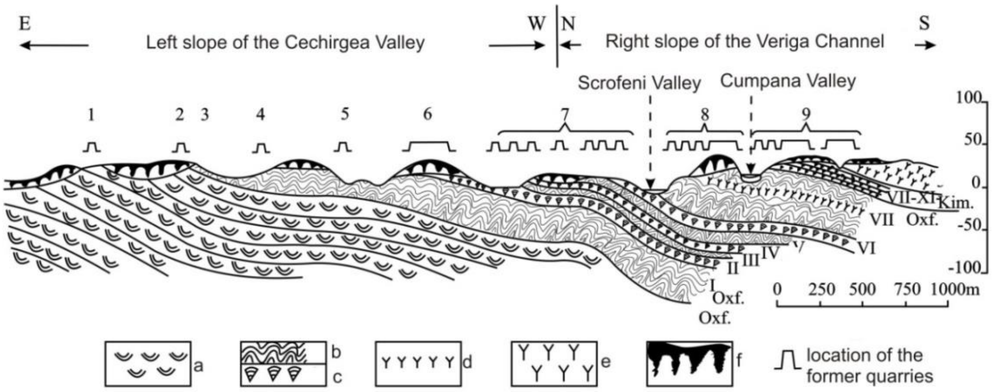

Fig. 1.2. Outcrop location along Cechirgea Valley and Veriga Channel: 1-9 former quarries; a- Visterna Member (microbial sponge limestone); b- megastromatolite-thrombolite mounds; c- microstromatolites; I-XI stromatolite-thrombolite levels; d- small colonial corals between the stromatolite levels; e- coral bioherms; f- Quaternary loess (modified from Drăgănescu, 1976).

Fig.1.3. Outcrop 5, Cechirgea Valley, transition from Visterna Member (sponge-microbial biostromes, middle Oxfordian) to Cechirgea Member (stromatolite-thrombolite mounds, middle-upper Oxfordian).

Description:

Along the left slope of Cechirgea Valley (outcrops 1 to 6) the upper part of the Visterna Member (over 10 meters thick) ix exposed, represented by medium bedded biostromes dominated by hexactinellid and lithistid sponges (microbial-sponge boundstone, bioclastic packstone-wackestone to floatstone). Sponges with diverse morphologies (pateliform, cylindrical, columnar, and branched) are represented by genera such as: *Platychonia, Cylindrophyma*, *Staroderma*, *Trochobolus*, *Craticularia.*

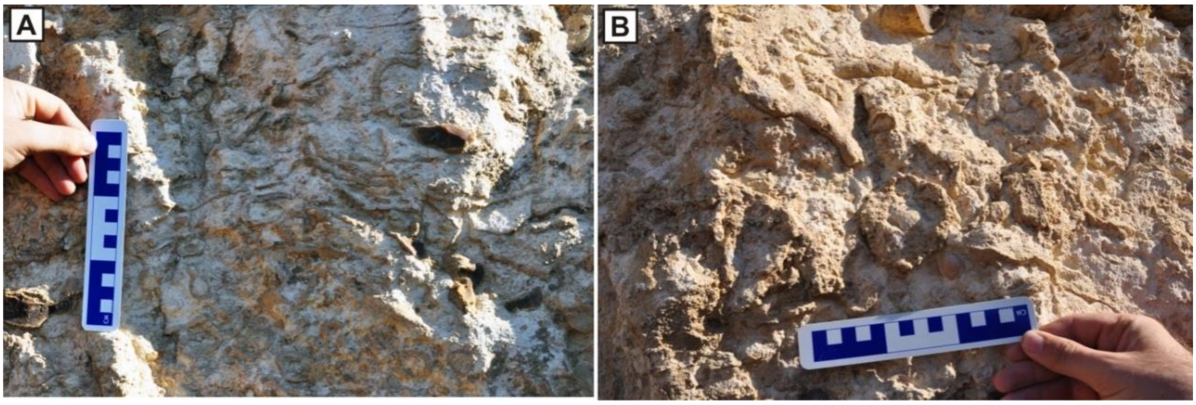

Fig.1.4. Topmost part of Visterna Member (middle Oxfordian): microbial-sponge limestones dominated by hexactinellid sponges with different morphologies (outcrop 6).

The following member of the Casimcea Formation, the Cechirgea Member, can be observed in outcrops 4 to 9, along Cechirgea Valley and Veriga Channel. The Cechirgea Member is 150-170 meters thick and is composed of an impressive succession of laminated, mostly carbonate organosedimentary deposits (reported here as stromatolite and thrombolite mounds) that were described in general lines for the first time by Drăgănescu as microstromatolites and megastromatolites (in Patrulius et al., 1976). The stratigraphic extension of Cechirgea Member ranges from the middle Oxfordian (Transversarium Zone) to the uppermost Oxfordian (Planula Zone, Galar subzone) (cf. Bărbulescu 1974, 1976). Drăgănescu (1976) recognized eleven (I-XI) successive stromatolitic levels with different macrostructres and thicknesses; for example, the first stromatolitic level (I) visible in outcrops 4 to 6, is almost 8-10 meters thick.

Although the stromatolite boundstone sequences from Cechirgea and Veriga valleys are spectacular especially considering their macrostructures named "*giant domal megastromatolites*" (by Drăgănescu, 1976), these laminated carbonates did not receive too much attention. Preliminary field and laboratory studies accomplished by our research team during the last years revealed several features that suggest a complex genesis of these laminated carbonates forming buildups. Several microfacies types were identified in the studied sections (outcrops 4 to 9): laminated stromatolite bindstone, domal stromatolite bafflestone, thrombolite microbial carbonates, peloidal bioclastic packstone with stromatolitic meso- and microfabric, peloidal bioclastic packstone-wackestone, intensively bioturbated (e.g. *Thalassinoides*) with stromatolitic meso- and microfabric; bioclastic intraclastic peloidal.

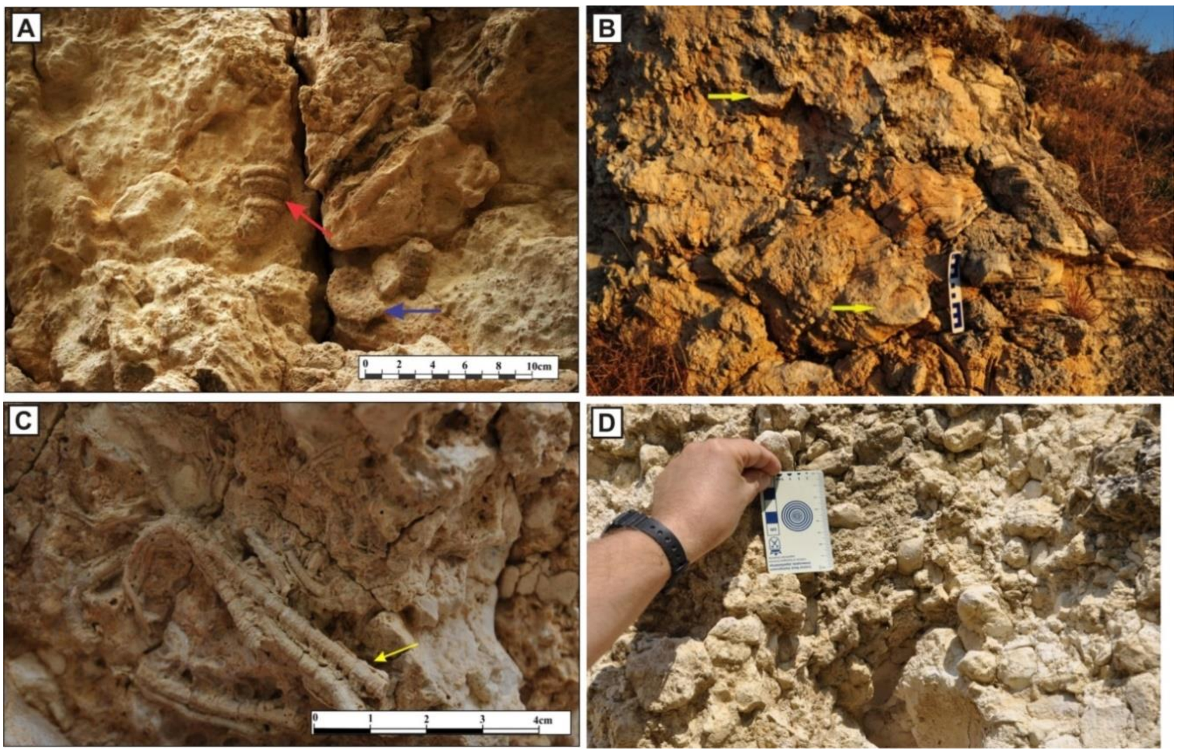

Fig. 1.5. Stromatolites of the middle-upper Oxfordian Cechirgea Member containing a rich and diverse invertebrate fauna: **A** - *Cypellia rugosa* (Goldfuss) (red arrow), *Hyalotragos patella* (Goldfuss) (blue arrow), outcrop 6; **B** - large hexactinellid sponges (yellow arrows) in tranversal section included within the laminae of the megastromatolites; **C** – serpulid worm tubes; **D** – terebratulid brachiopod clusters between the domal stromatolite structures.

floatstone-packstone; oncoidal floatstone and packstone; bioclastic grainstone-packstone; and mudstones

The megastromatolite and microstromatolite structures contain hexactinellid and lithistid sponges, bivalves, as well as rhynchonellid and terebratulid brachiopods that locally form large skeletal-mounds between the large domal megastromatolites. Numerous serpulid worm tubes were observed encrusting the stromatolites' laminae, along with rare bryozoans, small ostreoids and small thecideid brachiopods; belemnites, nautiloids and ammonites were also found associated with the stromatolites. Toward the uppermost part of the last stromatolitic level (XI), small (decimentric) colonial corals and fragments of disrupted colonial corals were observed within the stromatolitic buildups.

The microstromatolites consist of centimeter-sized planar to domal to columnar macrostructures (7-8 cm hight) with planar, undulated to crinkle or dendritic lamination; the lamination consist of an alternation between dark micritic laminae (sub-millimeter up to 1-2 mm in thickness) that in several samples contain fine peloids and bioclasts, and microsparitic laminae ranging between 2 to 3 mm in thickness.

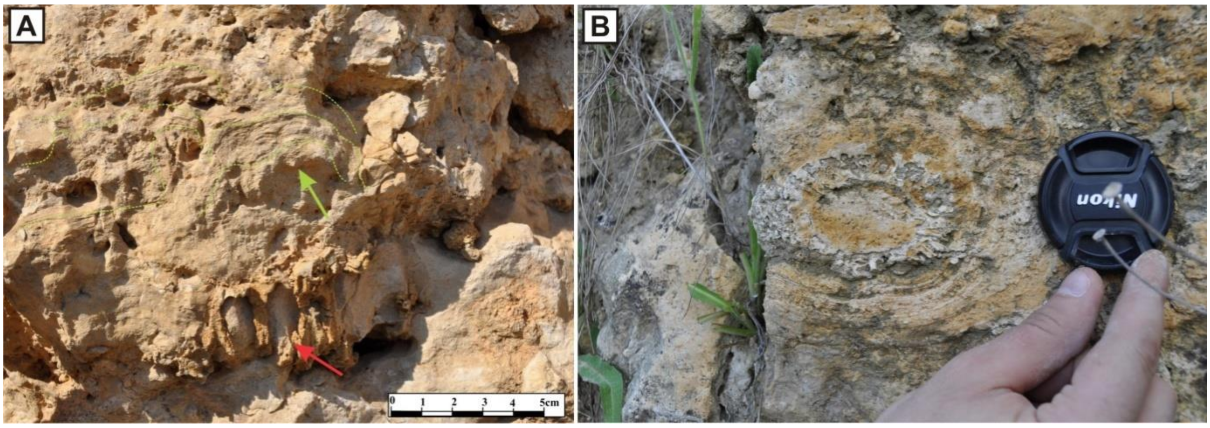

Fig. 1.6. Microstromatolites encrusting sponges in life position (**A**) or broken sponges in the substrate (**B**).

Macrostructures of the megastromatolites or stromatolite-thrombolite mounds consist of large domal-like macrostructures (almost 0.5-1.5-2 meters height/amplitude) and irregular “sinusoidal” or waved macrostructures (0.1-0.5 m amplitude and 0.1-0.2 m length along strike of the domical varieties), with draped sedimentary wedges of the domical stromatolite flanks. Several high domal macrostructures show steep, almost vertical slopes, with planar and wrinkle lamination (Fig. 1.7. C,D); in several outcrops the megastromatolites are forming large waved beds of 0.5 – 1.5 m thickness and a wave amplitude of 0.2 -0.5 m (Fig. 1.7. A,B). The internal macrostructure of the megastromatolites is dominated by convex layer-forming columnar, sinusoidal or waved textures. The interdomal space between the megastromatolites is filled with bioclastic grainstone-packstone, rich in brachiopods, crinoids, echinoids, bivalves. Usually the buildup interfaces are discrete; individual domal megastromatolites may interconnect laterally with adjacent megastromatolite domes forming complicated (sinusoidal, columnar or maze-like) structures (Fig 1.7. E,F).

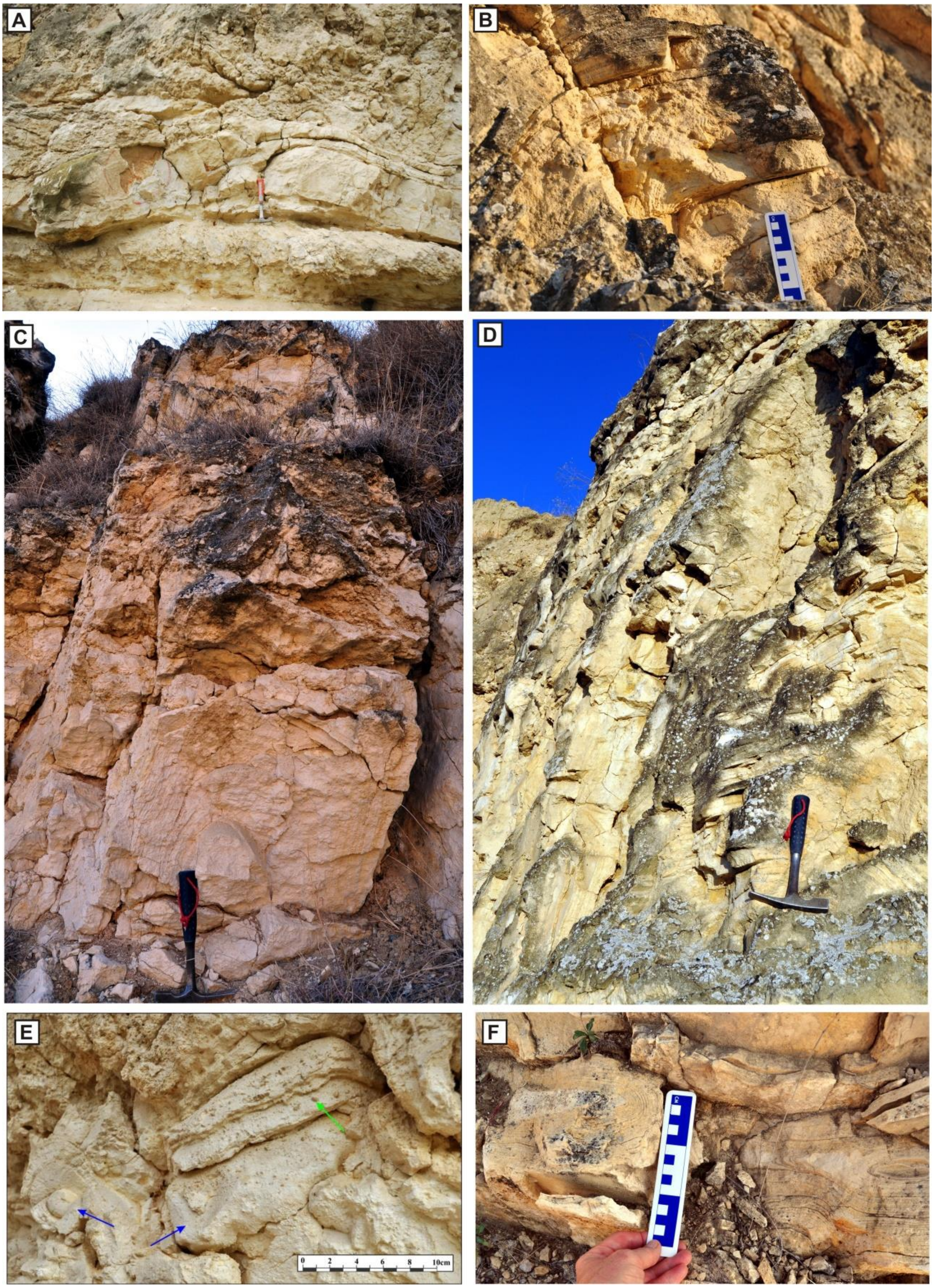

Fig. 1.7. Stromatolites – thrombolites forming large dome-like macrostructures and mounds, Cechirgea Member (middle-upper Oxfordian), Veriga Channel: **A** outcrop 8, **B-D** outcrop 7; **E** – hemisphaeroidal, multilobate stromatolites with contorted "roll-up" structures (blue arrow), serpulid worm tubes (green arrow); **F-** columnar stromatolites in transversal section.

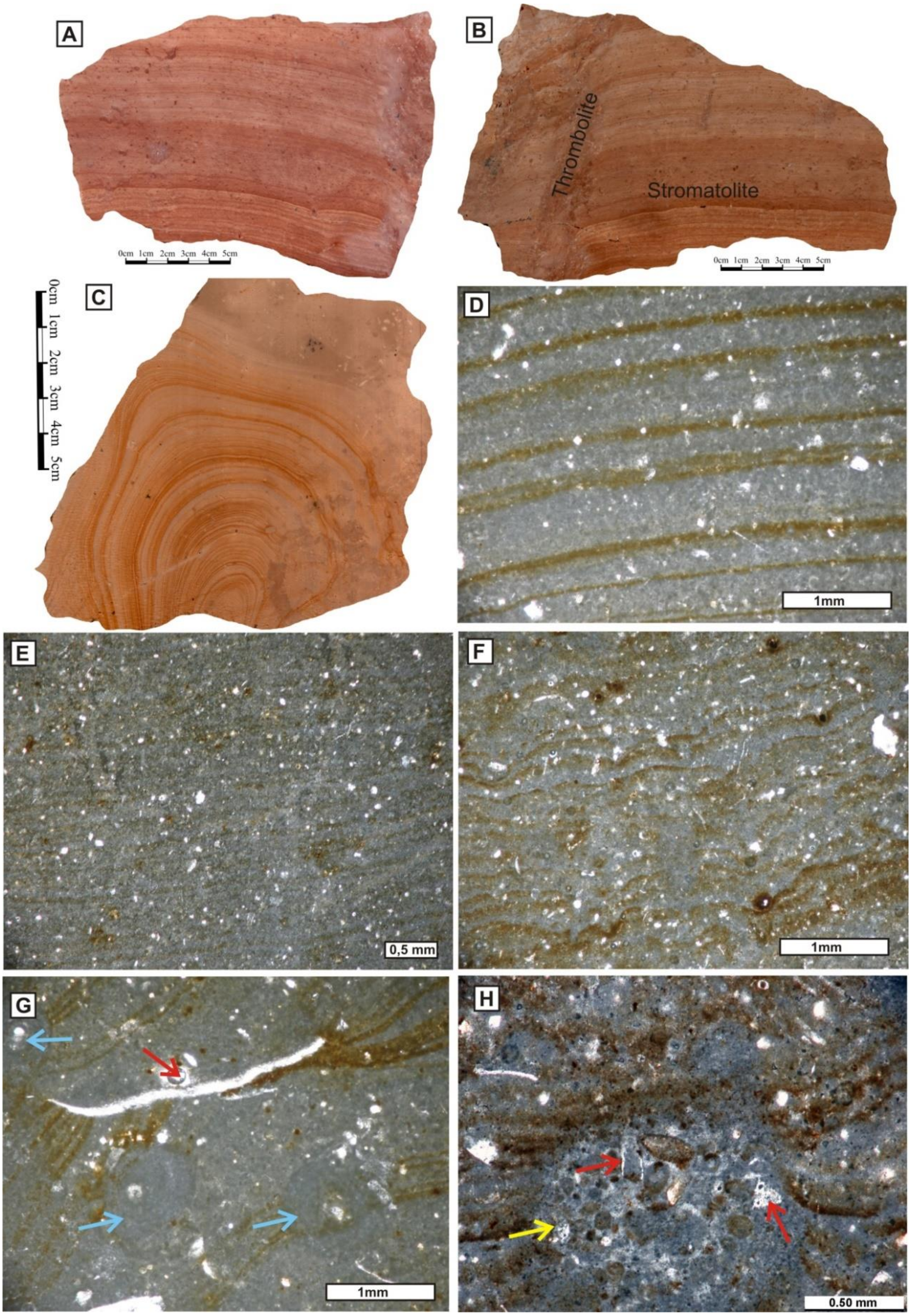

Fig. 1.8. A-C. The mesostructure of the megastromatolites ranges from planar to crinkle laminated (polished surfaces); Note in B a thrombolite structure interrupting the stromatolitic laminae. **E, F** – planar to crinkle laminae; **G -** *Saccocoma* ossicle (red arrow) and microencruster *Crescentiella* (blue arrows) interrupting lamination; **H -** sponge mummie (yellow arrow) producing the distortion of the laminae; *Saccocoma* ossicle (red arrows).

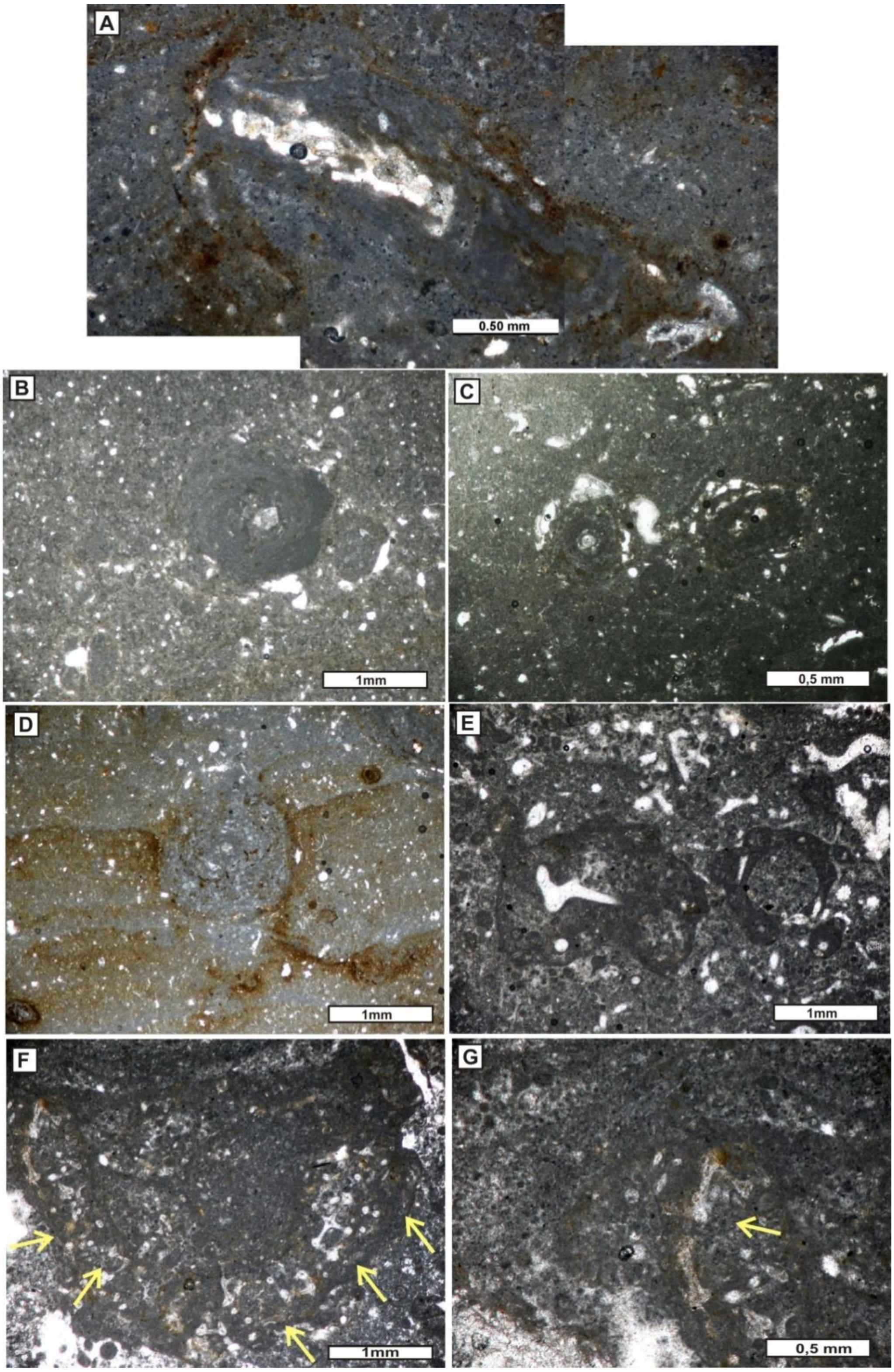

Fig. 1.9. A-D. *Crescentiella morronensis* (Crescenti, 1969) within the stromatolitic fabric; **C** - *Crescentiella* encrusted by serpulid worm tubes and benthic encrusting foraminifera; **E-G** sponge mummies within agglutinated stromatolitic fabric.

The mesostructure ranges from planar to largely convex, to crinkle laminated; the lamination consists of sheets of continuous laminae characterized by an alternation of dark (grey or ferruginous), sub-millimeter up to 2 mm thick micritic laminae, alternating with millimeter-sized laminae ranging between 3 to 5 mm in thickness; sometimes the laminae build up into convex-up domes (up to 10-15 mm in height) growing on the planar or wavy surface; usually the laminae form 0.2–10 cm wide folds, or contorted and "roll-up" structures (Figs. 1.7.E,F, 1.8. A-C).

The microstructures consist of an alternation of sub-millimetric grey and ferruginous laminae. The laminae are composed of several microfabrics: dense micrite and micropeloidal laminae; porous laminae with a microsparite matrix and abundant peloids; all these laminae contain small bioclasts, rare quartz grains and calcite pseudomorphs after dolomite crystals. The bioclasts are represented by crinoid ossicles (e.g., *Saccocoma*), planktonic bivalve shells, ostracods, and extremely rare foraminifera. Sponge mummies and spicules are also frequent.

One of the most striking features of the studied stromatolitic boundstones is represented by the high abundance of the microencruster *Crescentilla morronensis* within the stromatolite laminae (Fig. 1.9.). *Crescentiella morronensis* (Crescenti, 1969) is a microproblematicum interpreted as a nubeculariid foraminifer-cyanophycean consortium (Senowbari-Daryan et al., 2008), and has been reported from numerous carbonate platforms of the Tethyan realm as well as from deep-water microbial-sponge reefs from the epicontinental Tethyan shelf (Senowbari-Daryan et al., 2008; Pleş et al., 2017; Krajewski and Schlagintweit, 2018; Kołodziej and Ivanova, 2021, and references therein). A significant participation of *Crescentiella* in the formation of carbonate buildups was described by Schlagintweit and Gawlick (2008) who proposed a special type of Upper Jurassic reefs (or else a significant part of the reefs) dominated by microencruster-microbial-cement microframeworks, based upon data from the Northern Calcareous Alps of Austria.

In the upper part of the Cechirgea Member (stromatolitic levels VIII, IX, X) contains solitary corals and small colonies of branching, encrusting, globose and arborescent corals, along with abundant bioclasts debris. The last stromatolitic level (XI) is represented by domal megastromatolites, and is capped by medium bedded, coarse-grained whitish dolomites (almost 2-3 meters thick). The first massive coral bioherm of the Topalu Member occurs on the top of these dolomitised beds. The Topalu Member is almost 15-20 meters thick and consists of numerous massive coral bioherms laterally linked into a continuous biostrome. Over 69 species of corals were described by Roniewicz (1976) from here, and the associated rich invertebrate fauna (bivalves, gastropods, brachiopods, bryozoans, echinoids, crinoids, rare ammonites) was studied by Bărbulescu (1974). Several species of decapod crustaceans were described by Schweitzer et al. (2017). Rare ammonites reported by Bărbulescu (1974) from the topmost part of Cechirgea Member and the lowermost part of Topalu Member support their early Kimmeridgian age.

Fig. 1.10. The first massive coral bioherm from Topalu Member, lower Kimmeridgian, on the top of the uppermost, dolomitized stromatolite level.

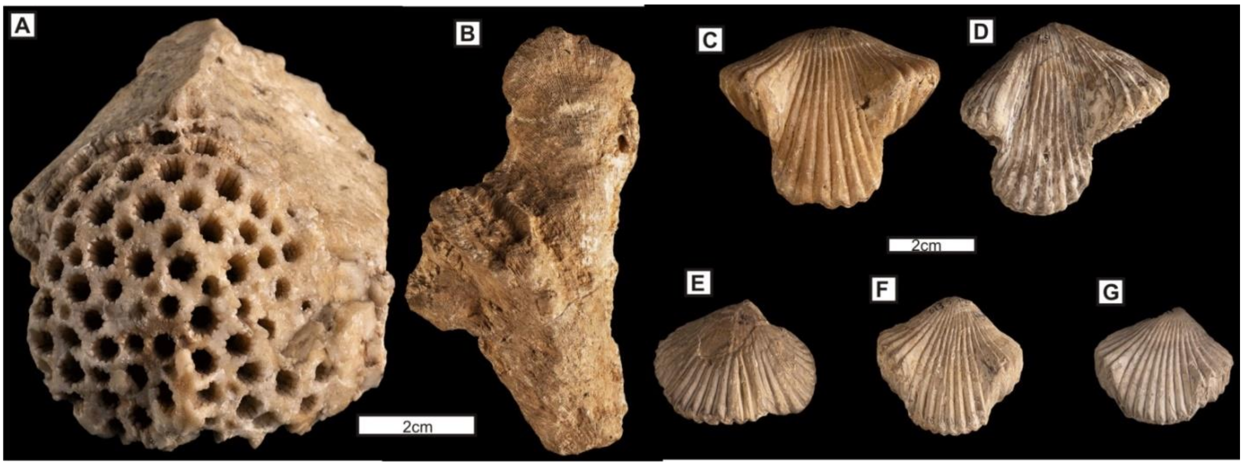

Fig. 1.11. Corals and brachiopods from the Topalu reef, lower Kimmeridgian, Veriga channel: **A** - *Adelocoenia radisensis* d'Orbigny 1850; **B** - *Clausastrea topalensis* Roniewicz ,1976; **C-G** - *Septaliphoria moravica* Uhlig 1882. (photo Gheorghe Ilinca)

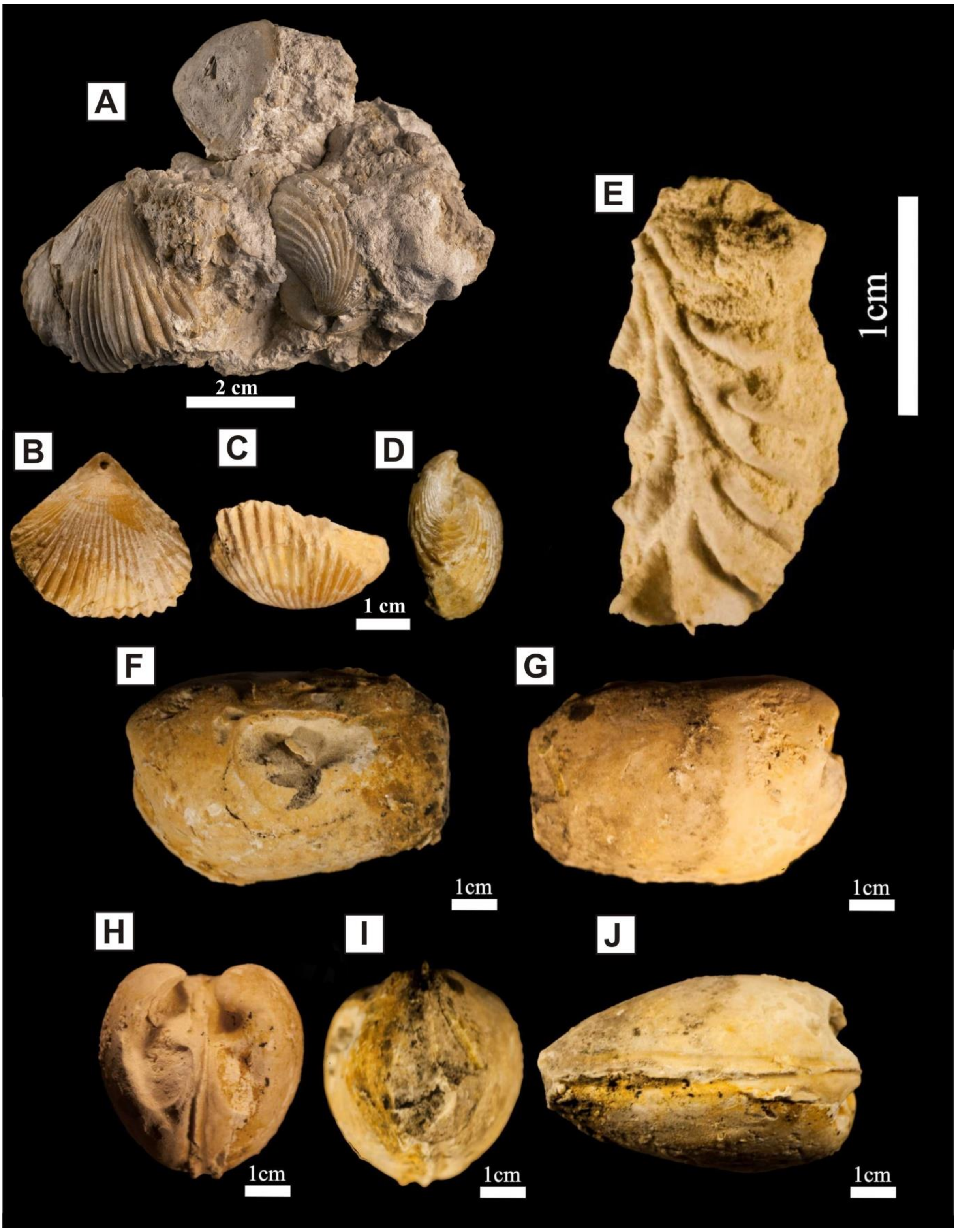

Fig. 1.12. Macrofauna from the microbial-sponge limestones (stromatolites) of Cechirgea Member, middle-upper Oxfordian: **A**-*Lacunosella cracoviensis* Quenstedt, 1871 encrusted with stromatolites; **B-D** - *Lacunosella cracoviensis* Quenstedt, 1871; **E** - *Actinosteron gregareum* (J. Sowerby, 1815**), F-J** - *Isoarca explicata* Boehm, 1881.

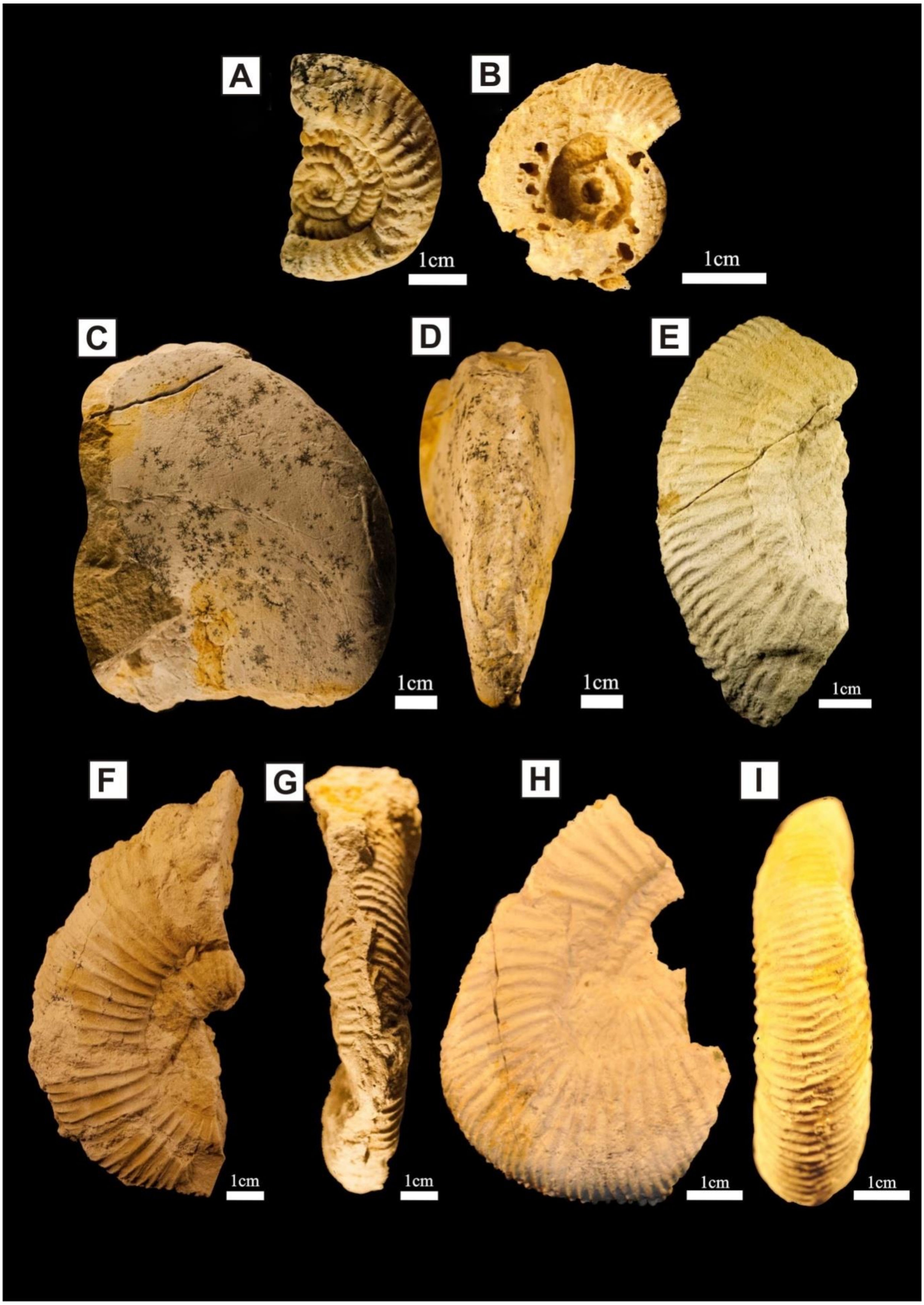

Fig. 1.13. Macrofauna from the stromatolites of Cechirgea Member, middle-upper Oxfordian: **A, B, E-I –** Perisphinctidae ammonites; **C-D** – nautiloid *Pseudaganides* cf. *aganiticus* (Schlotheim).

Fig. 1.14. Hexactinellid sponge *Cypellia* sp. from the stromatolites of Cechirgea Member, middle-upper Oxfordian. The sponge is completely silicified and encrusted with stromatolite laminae. Note the trace fossils on the microbial laminae.

Stop 2. Seimenii Mari

Marius Stoica, Iuliana Lazăr

Stratigraphy: Cochirleni Formation (Albian), Seimeni Formation (upper Badenian = Konkian), Cotu Văii Formation (middle Sarmatian s.l. = Bessarabian).

Location: Seimeni village, outcrops on the right bank of the Danube River (44°23'55.98''N; 28° 4'24.19''E).

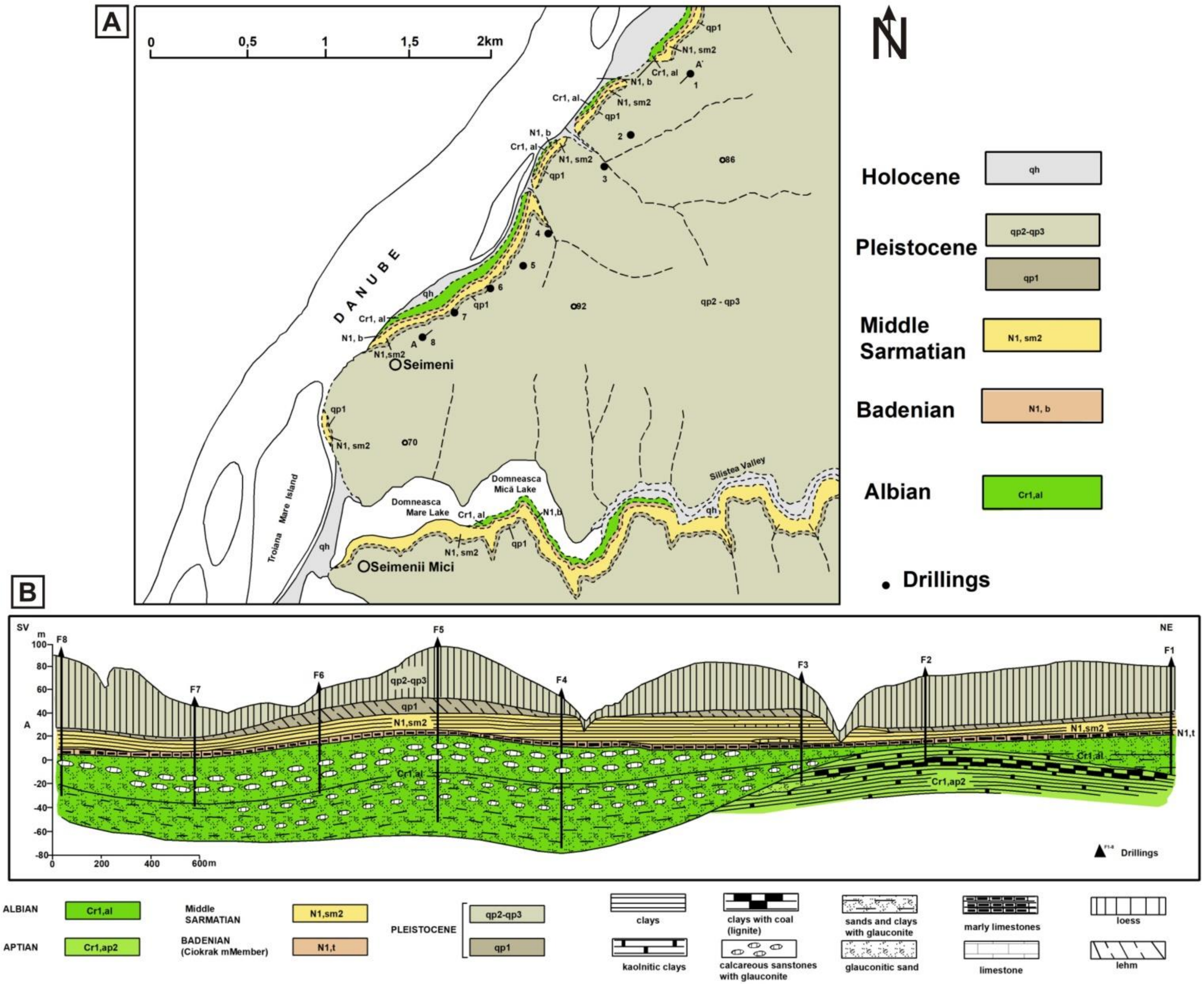

Fig. 2.1.**A-** Geological map of Seimeni area; **B-** cross-section on the right bank of Danube, north of Seimeni village (modified from from Chiriac, 1981)

Description: The section is exposed on the right bank of the Danube, in the Seimenii Mari village. The base of the section consists of Lower Cretaceous deposits represented by Albian glauconitic sandstones. At approximately 1 km north from Seimeni village, the upper part of the glauconitic sandstone contains a rich fauna of ammonites (*Anahoplites planus*, *Hysteroceras orbignyi*, *Mortoniceras* (*Durnovarites*) *perinflatum* and numerous other species representative for the middle and upper Albian) described by Chiriac (1981). The Albian deposits are unconformably covered by Konkian bioclastic limestones rich in mollusk shells (*Acantocardia barrandei shafferi*, *Cardita partschi*, *Anomia squanula*, *Anadara turonica*, *Chlamys varnensis*, *Corbula gibba*, *Ervilia pusila*, *Crassostrea angusta*, *C. crasssisima*, *Cubitostrea digitalina*, *C. adriatica*), and by sands and gravels of the Seimeni Formation. In the upper part of the section bioclastic limestones rich in bivalves (*Mactra* sp.) are exposed, representing the Cotu Văii Formation (middle Sarmatian s.l. = Bessarabian), on its turn covered by Pleistocene red clays and loess deposits.

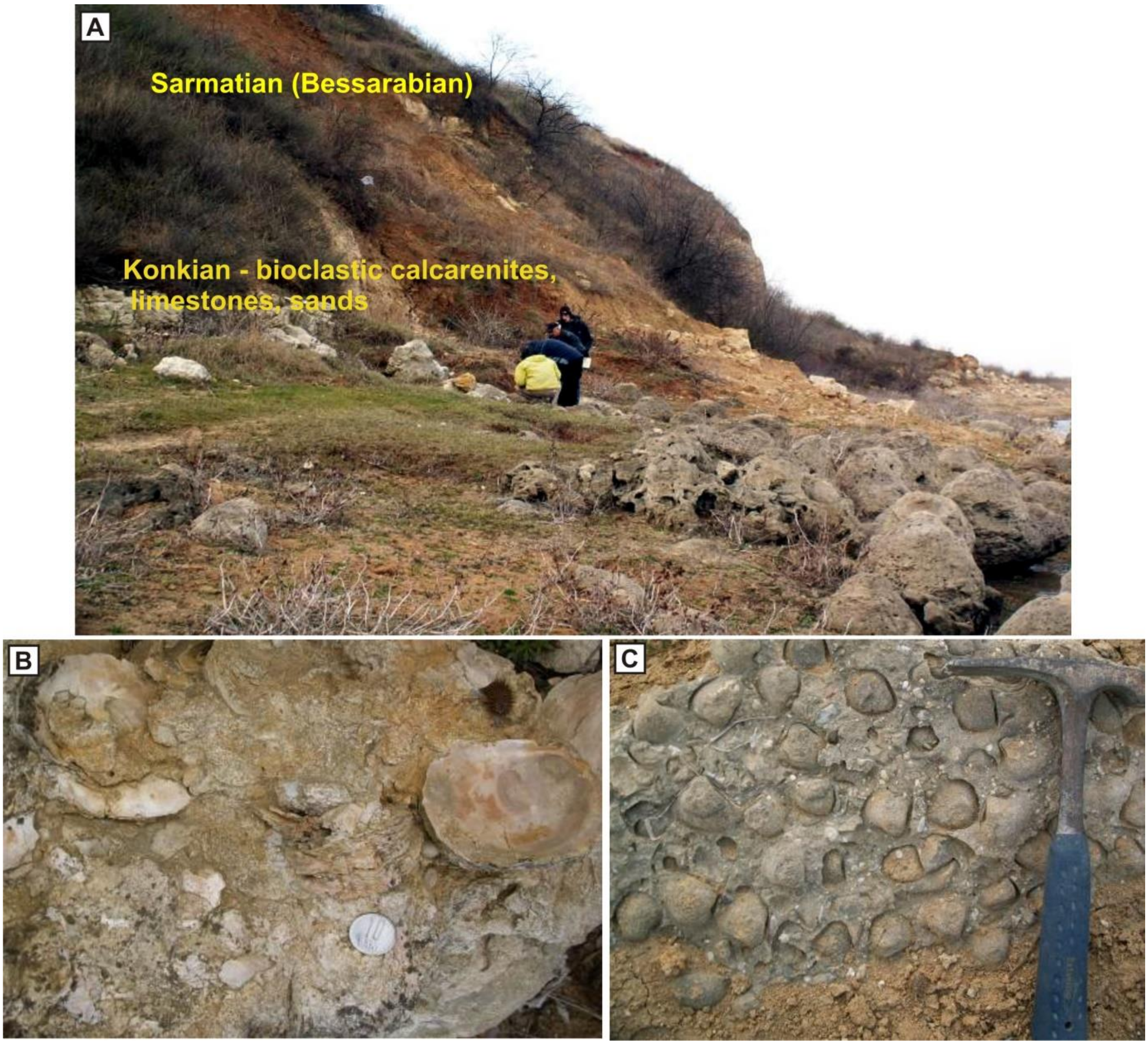

Fig. 2.2. A- Outcrop on the right bank of Danube, Seimenii Mari village; **B-** Konkian biocalcarenites with *Ostrea* shells; C- Sarmatian bioclastic limestone (the lower limestones unit) rich in *Mactra* shells.

Stop 3. Ramadan

Marius Stoica, Iuliana Lazăr

Stratigraphy: Ramadan Formation (lower Aptian), Gherghina Formation (middle-upper Aptian), Seimeni Formation (upper Badenian = Konkian), Cotu Văii Formation (middle Sarmatian = Bessarabian).

Location: South bank of Ramadan Lake (currently a dry lake), at 3 km north-east from Cernavodă city (44°20'54.00"N; 28° 4'5.93"E).

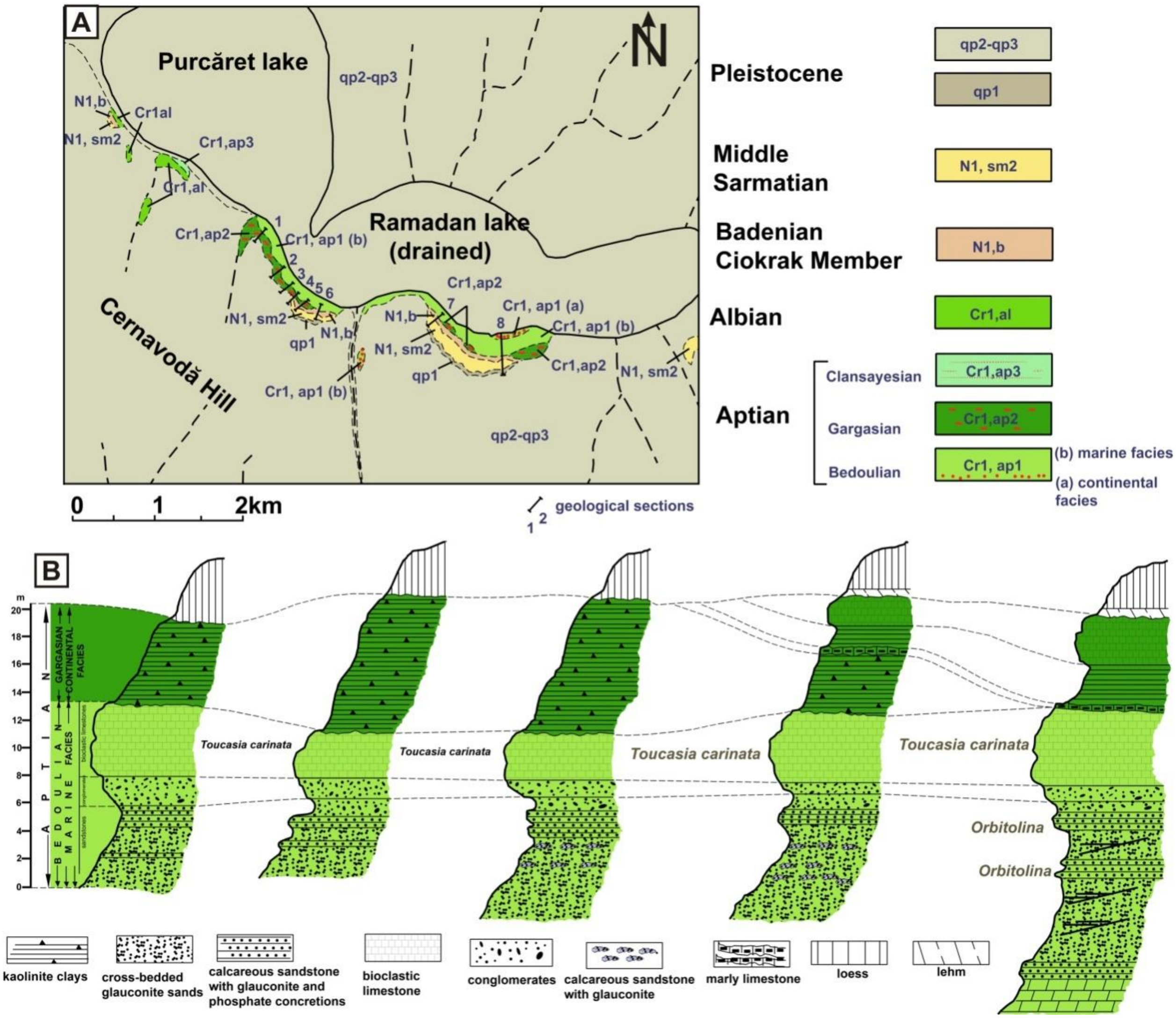

Fig. 3.1. Geological map and correlative sections on the south bank of Ramadan Lake (modified from Chiriac, 1981)

Description: On the south bank of the former Ramadan Lake, there is an almost 2 km long outcrop that exposes the Aptian deposits that underlie the Konkian clays and biogenic limestones of the Seimeni Formation, rich in marine faunas (*Crassostrea*, *Chlamys*, *Venus*, *Corbula*). The Seimeni Formation is unconformably covered by the Cotu Văii Formation (middle Sarmatian, Bessarabian) consisting of two units: the Greenish Clay Member (at the base) and the Lower Limestone Member, rich in *Mactra* shells, in the upper part.

The Ramadan Formation (lower Aptian) is represented by yellow cross-bedded sands, with frequent ferruginous concretions and *Orbitolina*-rich calcareous sandstone intercalations (especially towards the upper part of the sandy level). The Aptian sequence continues with thin-bedded conglomerates and bioclastic limestones rich in pachyodont bivalves (*Toucasia carinata*).

To the western part of the section, the lower Albian marine deposits are covered by kaolinite clays developed in continental-lacustrine facies. representing the Gherghina Formation (middle-upper Aptian).

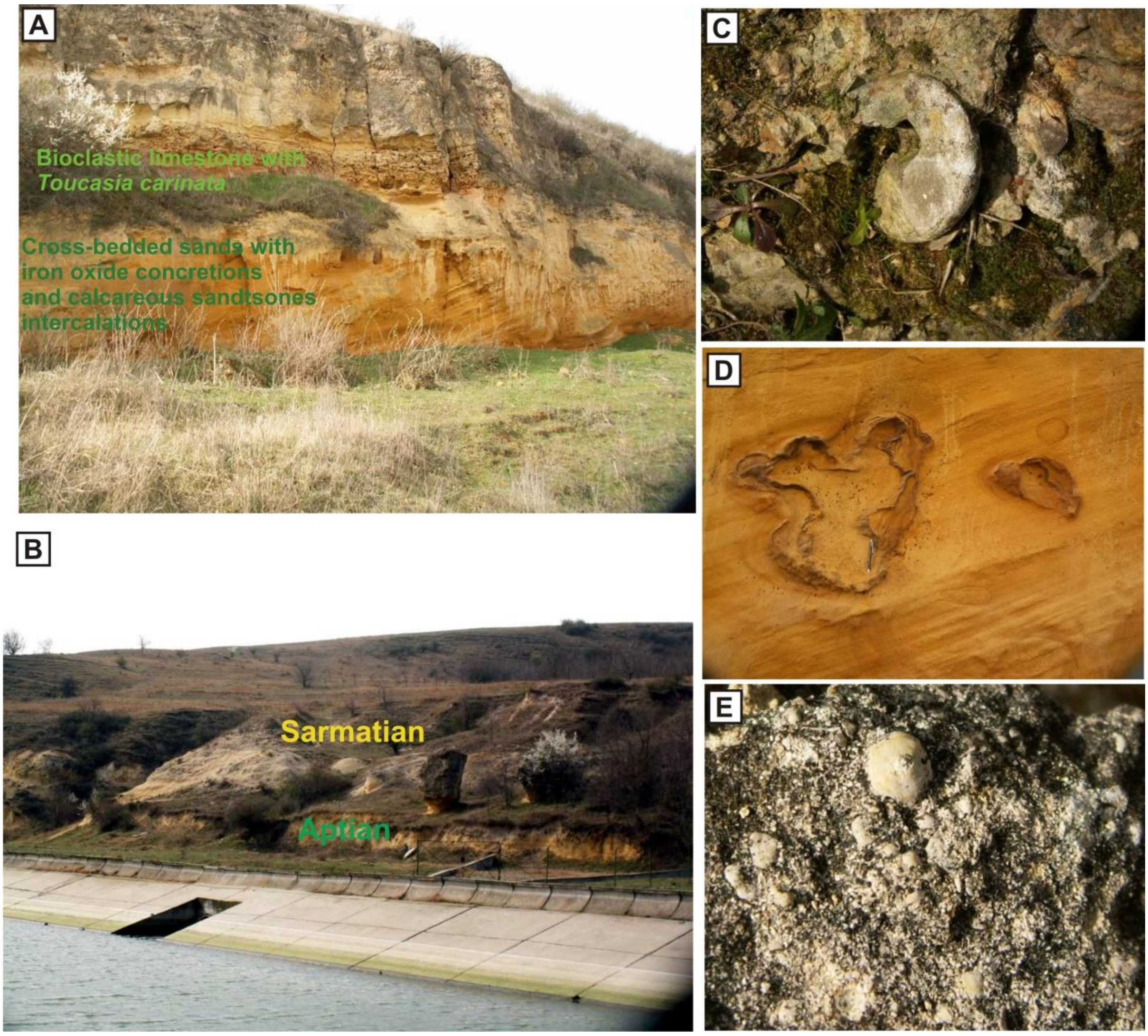

Fig. 3.2. Ramadan Lake Section; **A,B -** outcrops on the south bank of Ramadan Lake; **C,D,E -** lower Aptian deposits; C - bioclastic limestone with *Toucasia carinata*; D - cross-bedded sand with iron oxide concretions; **E -** calcareous sandstones with *Orbitolina.*

Stop 4. Cernavodă Bridge

Marius Stoica, Iuliana Lazăr

Stratigraphy: Cernavodă Formation (Berriasian –Valanginian), Ghergina Formation (Aptian - continental facies)

Location: Right bank of the Danube, south of the Cernavodă Bridge (44°20'18.11"N; 28° 1'7.36"E)

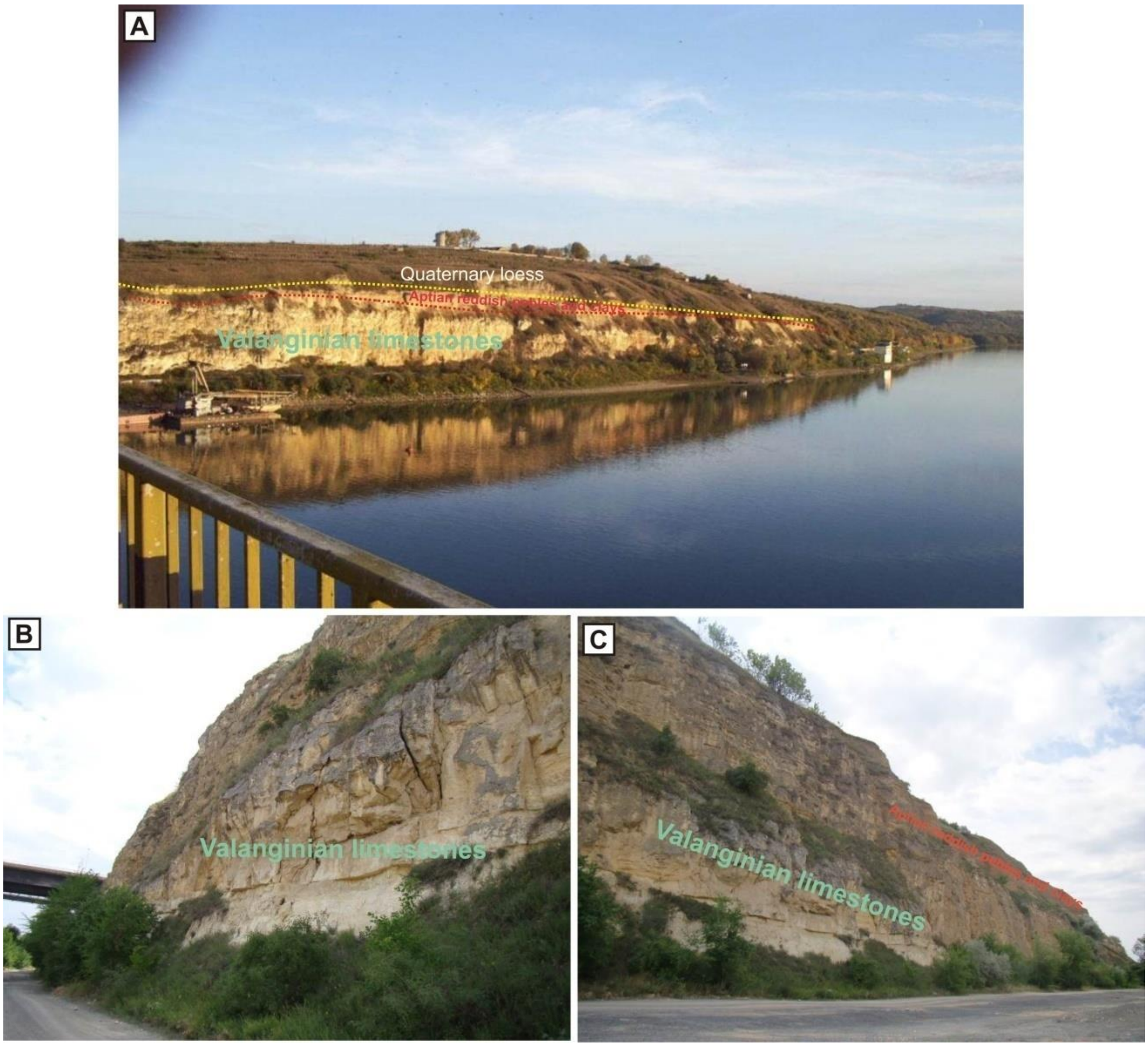

Fig. 4.1. A-C Cernavodă Bridge section on the right bank of Danube

Description:

The best exposure of the Cernavodă Formation can be followed on the western side of Hinog Hill, south-west from Cernavodă city. Here, on the right bank of the Danube River, a continuous exposure of a sub-horizontal, about 35-38 m thick limestone sequence extends upstream from the Cernavodă railway bridge toward the Cernavodă waterworks (for about 1.25 km distance).

The carbonate succession from Cernavodă Bridge represents the type section of the Cernavodă Formation, pro parte Aliman Member. The Cernavodă Formation in this area is represented by the Hinog and Aliman members. The Hinog Member (Berriasian) and the base of the Aliman Member (lower Valanginian) are not exposed in this section, being identified only in boreholes close to Hinog.

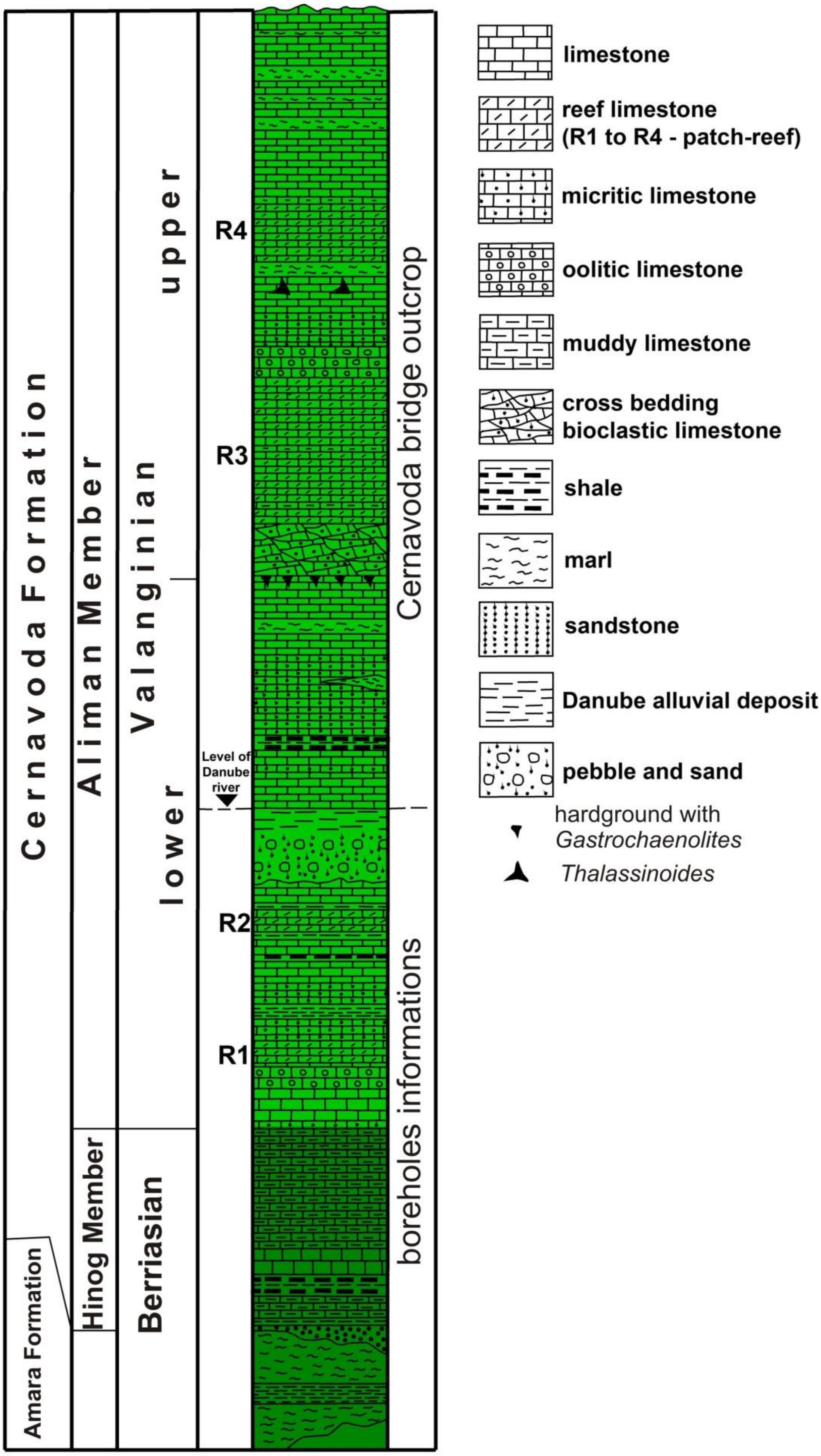

Fig. 4.2. Synthetic log of the Cernavodă Bridge section (modified from Neagu *et al*., 1997)

Shallow marine carbonate deposits of the Aliman Member (Valanginian) crop out in the Cernavodă Bridge section, composed of ooidal bioclastic limestones, peletal limestones with cross-bedding and bioturbations, massive bioclastic – microcoprolitic limestones, and sponge – microbial buildups with encrusting and branched sponges.

According to Dragastan *et al.* (1988) this carbonate sequence was generated in intertidal to upper subtidal environments, as demonstrated by the presence of typical intertidal patellids and nerineids, as well as in the upper subtidal environments, indicated by pachyodonts, ostreids, pleurotomariids and brachiopods. In the lower part of the section, micritic-pelmicritic limestones are intensely bioturbated, and the base of there is a bed encrusted with thin ferruginous crusts representing a hardground surface perforated by abundant *Gastrochaenolites* borings. This type of boring was produced by endolithic bivalves, and occurs abundantly on hard carbonate substrates from the Jurassic to the Recent. The ichnogenus *Gastrochaenolites* is useful for paleoenvironmental interpretations, as it indicates distal intertidal to proximal subtidal environments with reduced rate of sedimentation.

Four carbonate buildups (R1-R4) were identified in the middle and upper part of the section by Dragastan *et al.* (1998). The buildups consist of massive limestone (6 to 10 meters thick) suggesting a vertical-growing tendency. The core of the buildups is represented by crust- or dome-like colonies of demosponges (chaetetides and spongiomorphids). Around the sponge core, successive assemblages composed of pachyodonts shells (*Matheronia baksanensis*) form tabular biostromes that pass laterally to bioclastic limestone containing numerous gastropods (*Nerinea, Ampullina, Harpagodes, Purpuroidea, Leviathania*). The carbonate buildup R4 shows a core made of *Steinerella loxola*, a fringed ramified colony accumulated over a thicness of 2 m. *Lithocodium* crusts, corals (Stylinidae), calcareous bioclastic breccia with sponge debris, algae and foraminifers are also present. The buildup R4 displays two growth trends, reflecting a vertical tendency induced by the *Steinerella* colonies and a lateral growth trend, produced by bioclastic breccia cemented by *Lithocodium* crusts and micro-reefs of *Actiostromaria*, *Axiparietes* or *Siphonostroma*. Toward the top, a pachyodont-rich bed (*Monopleura valangiensis*) covers the bioconstruction. Biostromes with numerous gastropod shells (*Nerinea*, *Neritopsis*, *Nerita*, *Saulea*) occur around the buildup (Dragastan *et al*., 1998).

Toward the top of the section, the upper Valanginian limestones are overlain by reddish detrital continental deposits (pebbles and clays) of the Gherghina Formation (Aptian).

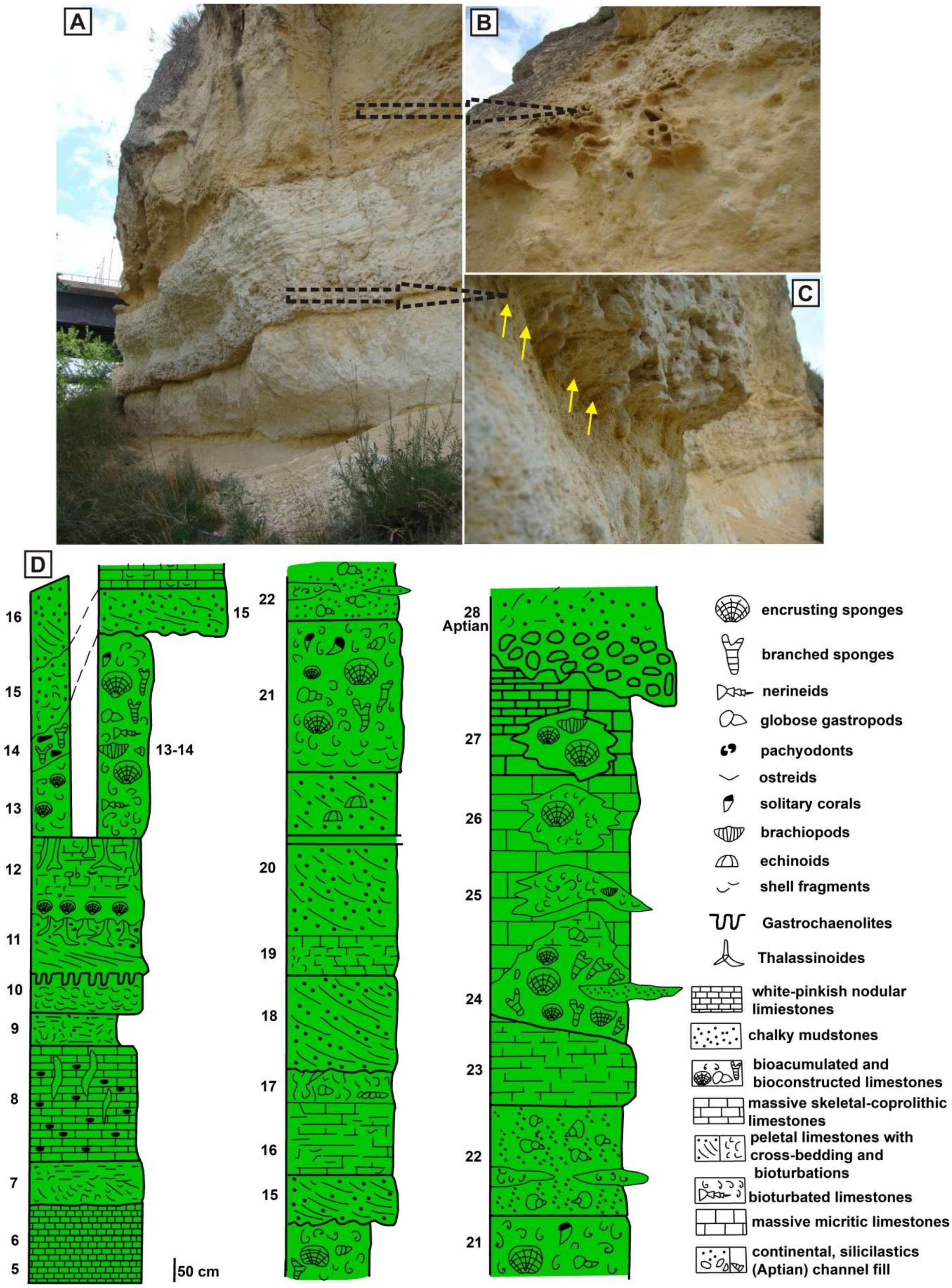

Fig. 4.3. A-C. Outcrop details from the lower part of the Cernavodă Bridge section: **B** – first microbial-sponge buildup; **C**- *Gatrochaenolites* borings perforating a hardground surface; **D** - Detailed logs of the Valanginian carbonate deposits from the Cernavodă Bridge section (modified from Neagu *et al*., 1997).

Second day: 17 September 2023

Stop 5. Murfatlar Quarry

Marius Stoica, Mihaela Melinte-Dobrinescu, Iuliana Lazăr

Stratigraphy: Murfatlar Formation (Santonian - Campanian)

Location: Quarry located south of Murfatlar (Basarabi) Village, Southern Dobrogea, (44°10'1.70"N; 28°24'12.81"E)

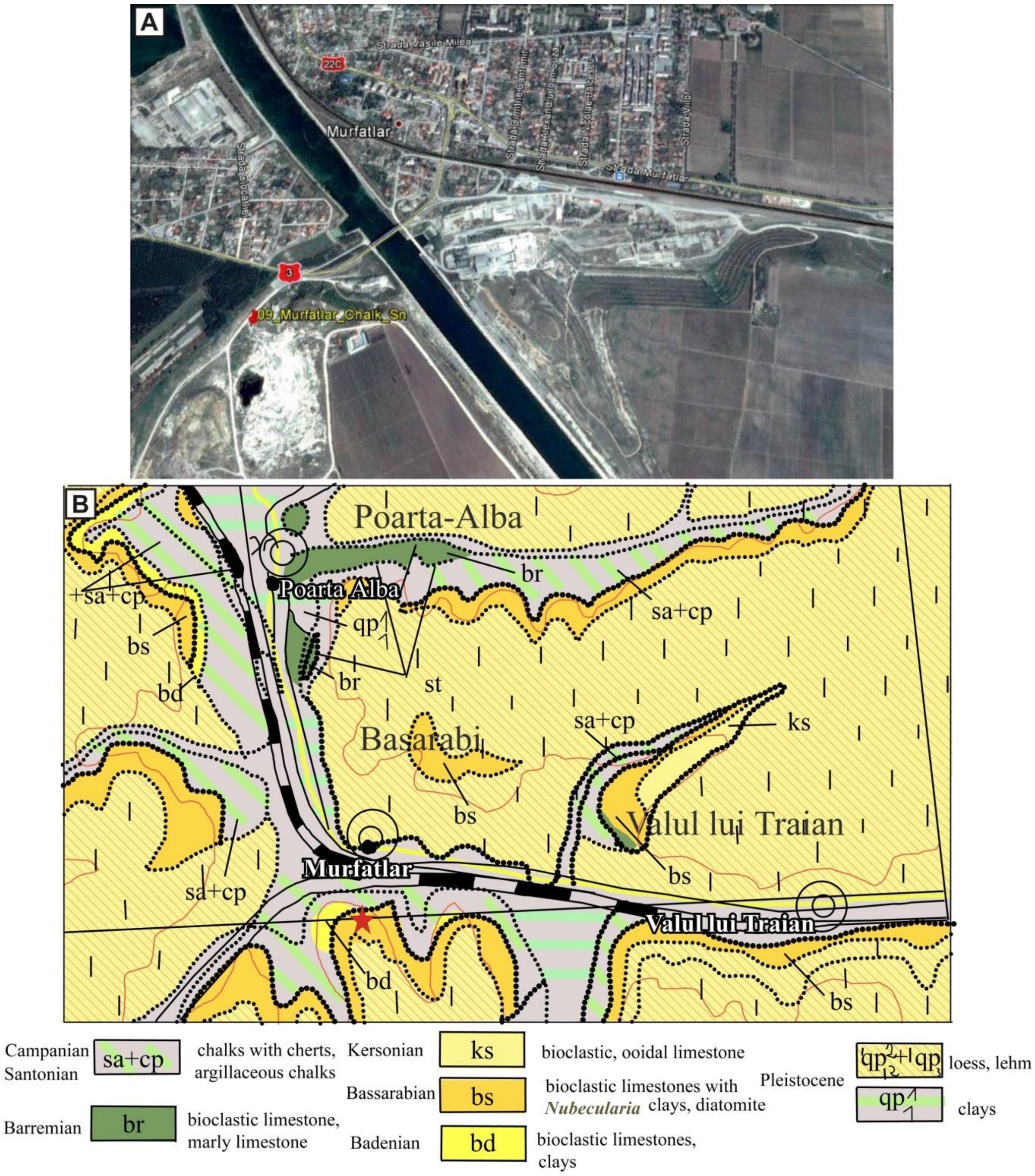

Fig. 5.1. **A** - Location of Murfatlar quarry (Google Earth); **B**- Geological map of the Murfatlar area (modified from Chiriac et al., 1968)

Description: The Senonian deposits trangressively cover the older Jurassic and Cretaceous sediments of Southern Dobrogea. The succession starts with basal microconglomerates with phosphate concretions, passing laterally to chalky sands and sandstones. These are overlain by Santonian glauconitic sandstones with echinoids (*Micraster coranguinum, Echinocorys vulgaris, Conulus oblongus*), brachipods and *Inoceramus* sp. (Mutihac, 2010).

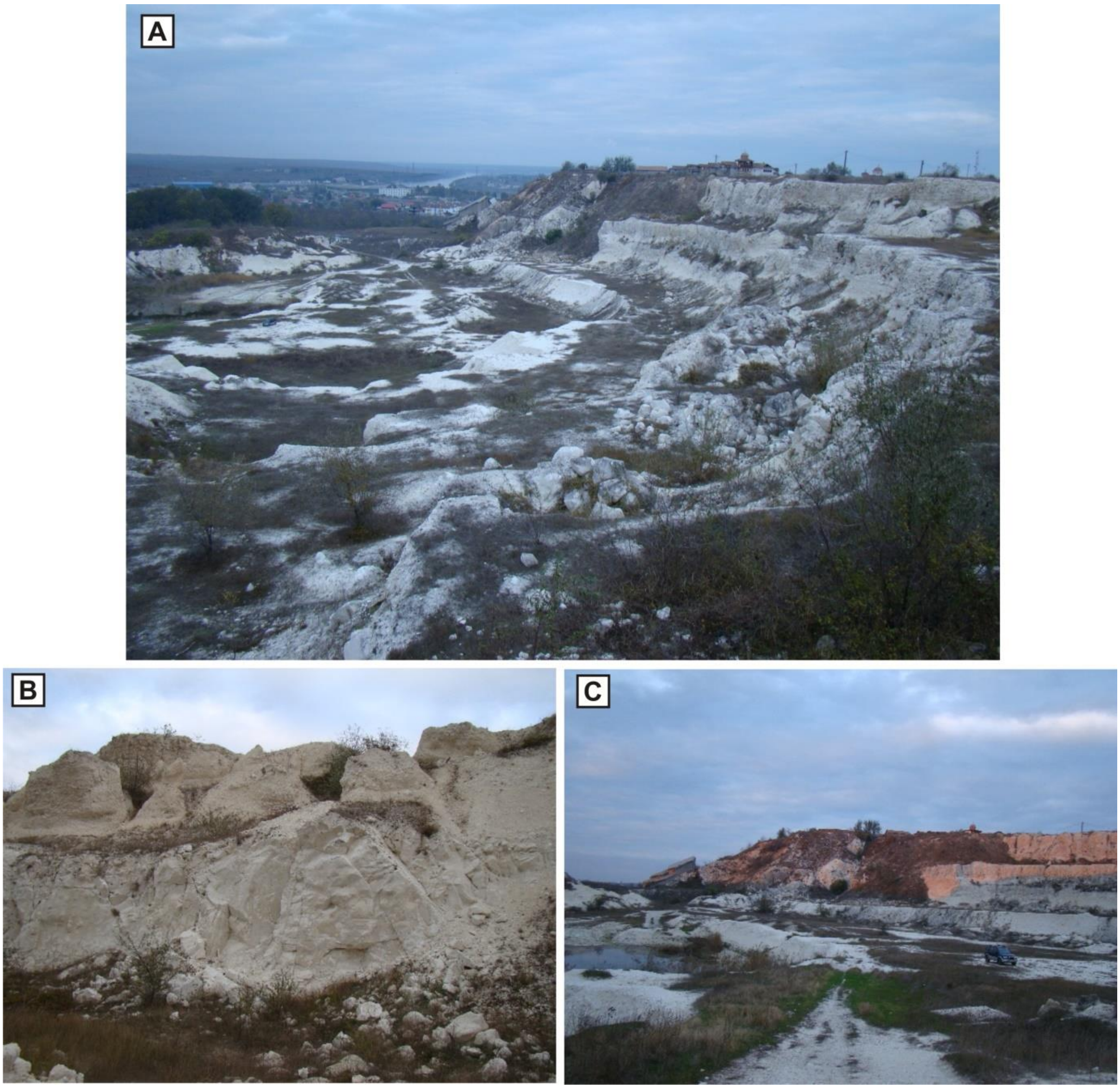

Fig. 5.2. Murfatlar Quarry: **A, B** – exposures of the Murfatlar Formation, grey-whitish argillaceous chalks overlain by yellowish clays and whitish, massive chalky limestones; **C** – the Basarabi-Murfatlar Cave Complex, carved in chalks.

In Murfatlar (= Basarabi) locality, the stratotype of the Murfatlar Formation is exposed in a large quarry, made up of grey-whitish argillaceous chalks, overlain by yellowish clays and whitish, massive chalky limestones towards the top (Avram et al., 1998; 1993; Ion et al., 1997). The planktonic foraminifera assemblages, assigned to the *Dicarinella asymmetrica* up to *Globotruncana ventricosa* zones (Neagu, 1987), indicate a Santonian up to Early Campanian age. A rich macrofauna is preserved in the upper part of the chalky limestones (Ion and Szasz, 1994), including echinoids (*Micraster* spp. and *Offaster pillula*), bivalves (e.g., *Inocermanus muelleri*), brachiopods, bryozoans, and belemnites (*Belemnitella mucronata*).

The calcareous nannofossil assemblages are very rich and diversified (Melinte-Dobrinescu et al., 2020), including long-ranging taxa, but also nannofossils with biostratigraphic significance, such as the successive FO (first occurrence) of *Broinsonia parca* subsp. *parca and Arkhangelskiella cymbiformis* that are latest Santonian events, followed by the FO of *Ceratolithoides aculeus*, which occurs at the top of the Early Campanian. These events cover the calcareous nannofossil biozones UC13-UC15 of Burnett (1998).

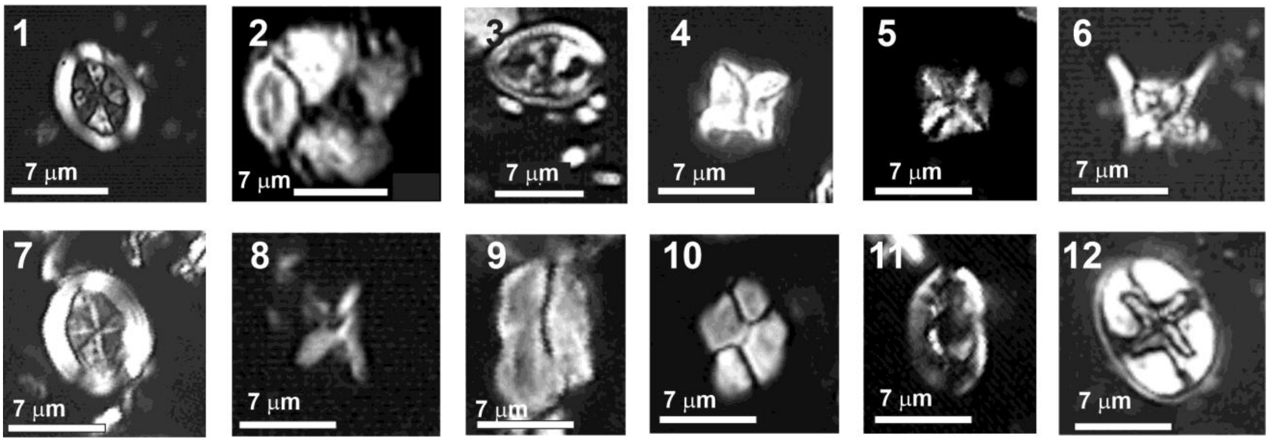

Fig. 5.2. Light microscope microphotographs in N+ (crossed nicols) of calcareous nannofossils from Murfatlar Quary. **1.** *Arkhangelskiella cymbiformis* Vekshina, 1959; **2.** *Petrarhabdus copulatus* (Deflandre, 1959) Wind & Wise *in* Wise, 1983; **3**. *Tranolithus orionatus* (Reinhardt, 1966a) Reinhardt, 1966b; **4**. *Quadrum gartneri* Prins & Perch-Nielsen *in* Manivit et al., 1977; **5**. *Micula staurophora* (Gardet, 1955) Stradner, 1963; **6**. *Micula concava* (Stradner *in* Martini & Stradner, 1960) Verbeek, 1976; **7**. *Broinsonia parca* subsp. *parca* (Stradner, 1963) Bukry, 1969; **8**. *Ceratolithoides aculeus* (Stradner, 1961) Prins & Sissingh in Sissingh, 1977; **9**. *Lucianorhabdus cayeuxii* Deflandre, 1959**; 10**. *Rhagodiscus splendens* (Deflandre, 1953) Verbeek, 1977**; 11**. *Calculites obscurus* (Deflandre, 1959) Prins & Sissingh in Sissingh, 1977; **12**. *Eiffellithus eximius* (Stover, 1966) Perch-Nielsen, 1968.

The locality of Murfatlar (known as Basarabi between 1924–1965 and 1975–2007) is famous for its medieval (9th *century) churches, crypts and tombs that are preserved in the Basarabi-Murfatlar Cave Complex, carved inside a chalk hill. The inscriptions found at this site are in Greek and Old Slavic languages. The Murfatlar area is also famous for its vineyards producing organic white, red, and rosé wines.*

Stop 6. Credinţa / Ciobăniţa Quarries

Marius Stoica, Iuliana Lazăr

Stratigraphy: Cotu Văii Formation, sandy facies, middle Sarmatian (Bessarabian)

Location: Credinţa Quarry (43°58'43.05''N; 28°13'40.63''E) NW from Credinţa Village / Ciobăniţa Quarry (44° 0'19.03''N; 28°16'50.40''E) in the sothern exit of Ciobăniţa Village.

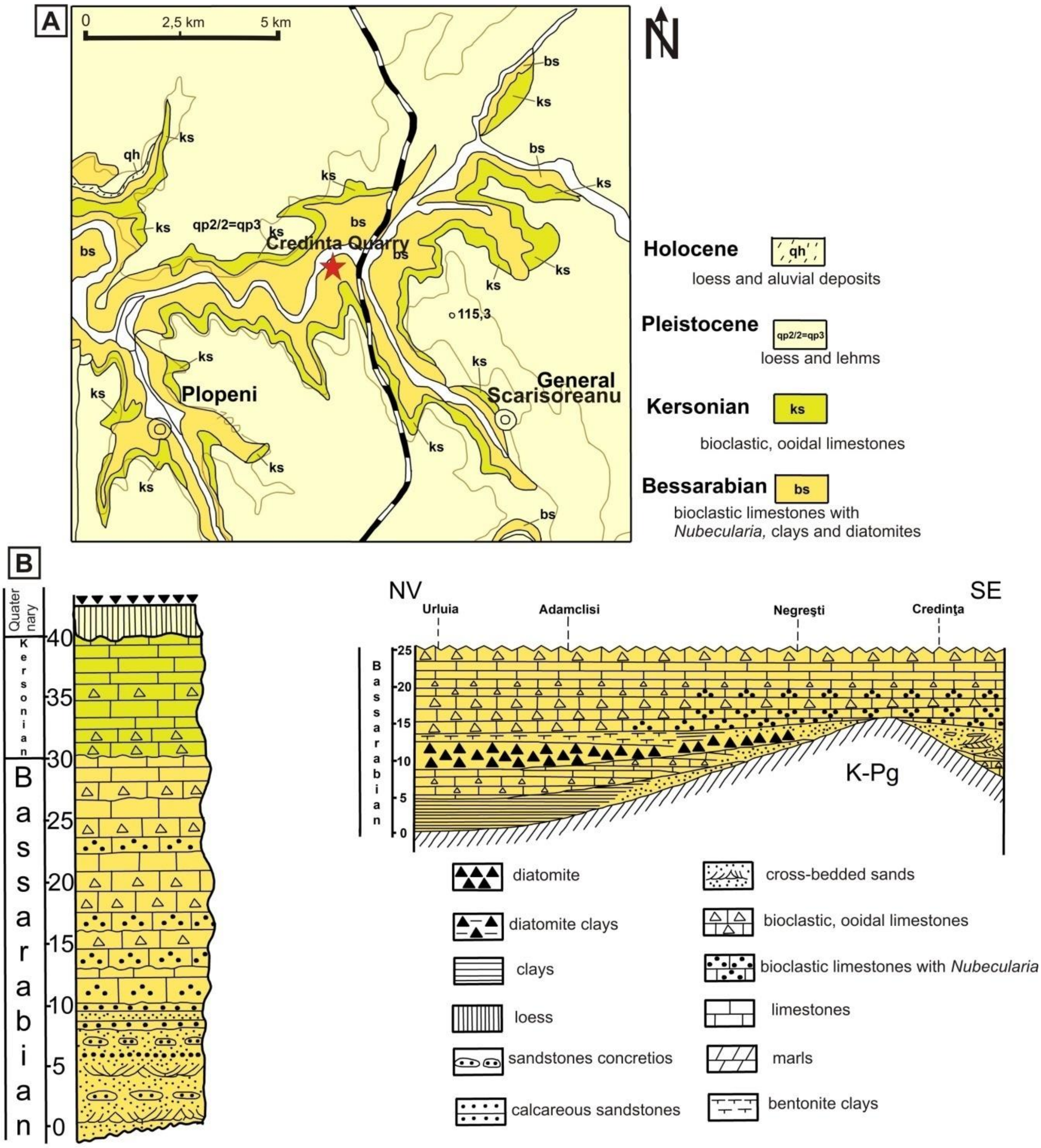

Fig. 6.1. A - Location of the Credinţa quarry on the geological map of the Mangalia area (modified from Chiriac and Mînzatu, 1967); **B -** Litostratigraphical log of the Sarmatian deposits from Credinta quarry and schematic cross-section between Urluia and Credinţa localities (modified from Grigorescu and Dinu, 1976).

Description: The small quarry near Credinţa locality exposes whitish-yellowish quartz sandy deposits that belong to the Cotu Văii Formation - named "the quartzose sand member" or "the Credinţa Sand" by Grigorescu and Dinu (1978). The sand succession reaches up to 10-12 meters in thickness, and is wedged between the "lower limestones unit" and the "upper limestone unit" (12-14 meter thick). From these deposits, Grigorescu (1976) described a rich vertebrate fauna (fish, birds, turtles, seals, cetaceans). The quartz sands succession is composed of a small number of lithological units: the lower one is represented by a heterogeneous unit with silts and sands rich in iron oxides, with cross-bedded lamination; the second unit is dominated by highly sorted sands (80-85%); the third unit is represented by sands with coarse-grained intercalations. Towards the upper part of the sandy sequence, calcareous sandstones and calcarenites become more frequent. Also, sandy concretions with carbonate cement can be observed in the upper part of this unit. Various source areas provided the detrital material for these deposits: Ediacaran "green schists" from Central Dobrogea, granites and gneisses from North Dobrogea, as well as Cretaceous and Eocene sedimentary rocks that are uncomformably overlain by the Sarmatian deposits in the area. The transportation of the material was mainly marine and aeolian.

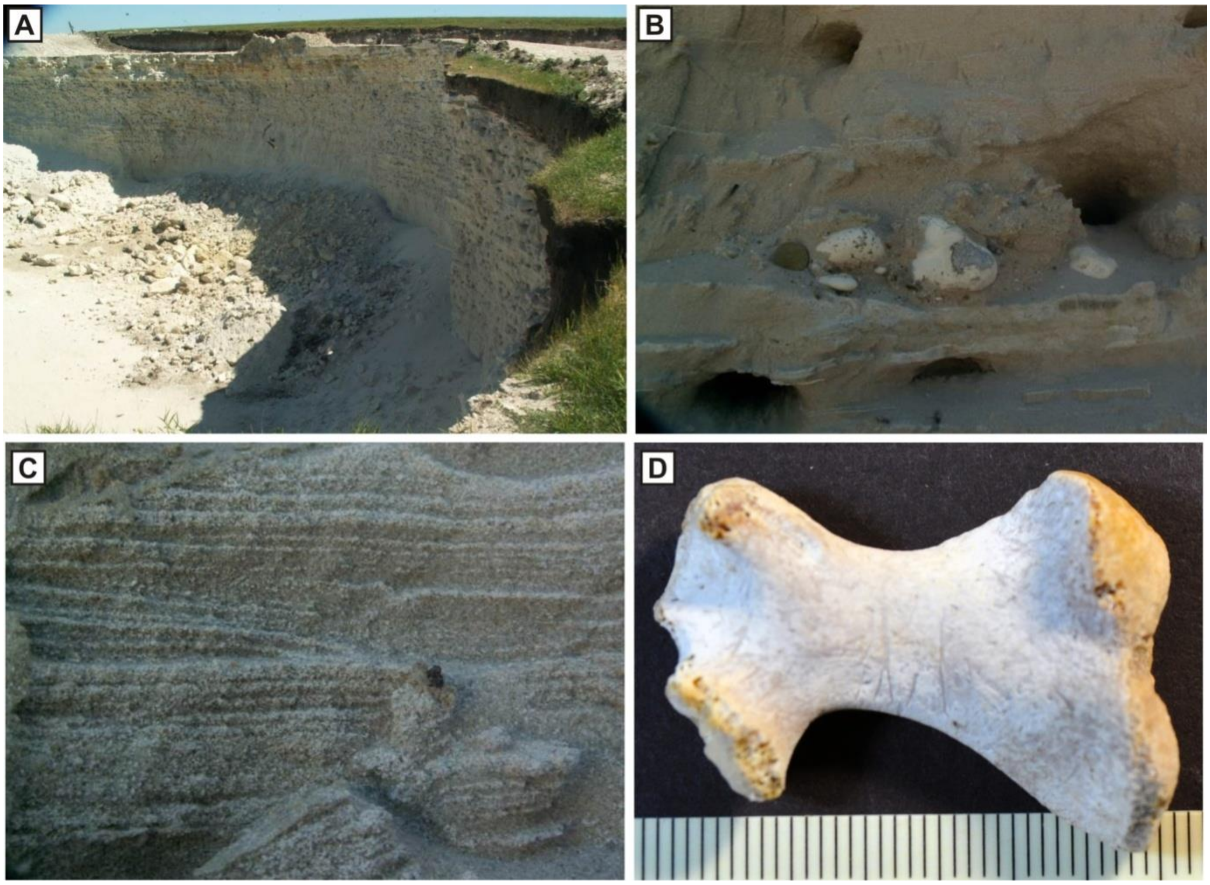

Fig.6.2. A- Sandy Sarmatian (Bessarabian) deposits (Cotu Văii Fm.) exposed in Credinta quarry; **B** pebble intercalations in sandy deposits; **C -** cross-bedded quartzose sand; **D -** fossil seal (*Phoca*) femur from Credinţa quarry (Stoica, M. collection).

Stop 7. “*Sandstones and Limestone walls*” from Petroşani village

Mihaela Melinte-Dobrinescu, Iuliana Lazăr

Stratigraphy: Peştera Formation (Cenomanian) and Cotu Văii Formation (Middle Miocene, Sarmatian, Bessarabian)

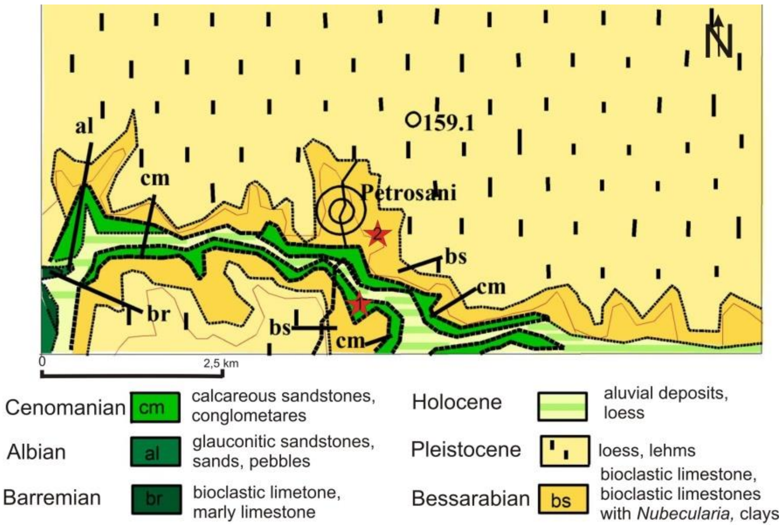

Fig. 7.1. Location of the visited sections on the geological map of the area: 1 Canaraua Mare Valley, Cenomanian/Bessarabian deposits, 0.5 km south of Petroşani Village; 2 – “*limestone walls*” from Petroşani Village (Bessarabian) (modified from Chiriac et al., 1968).

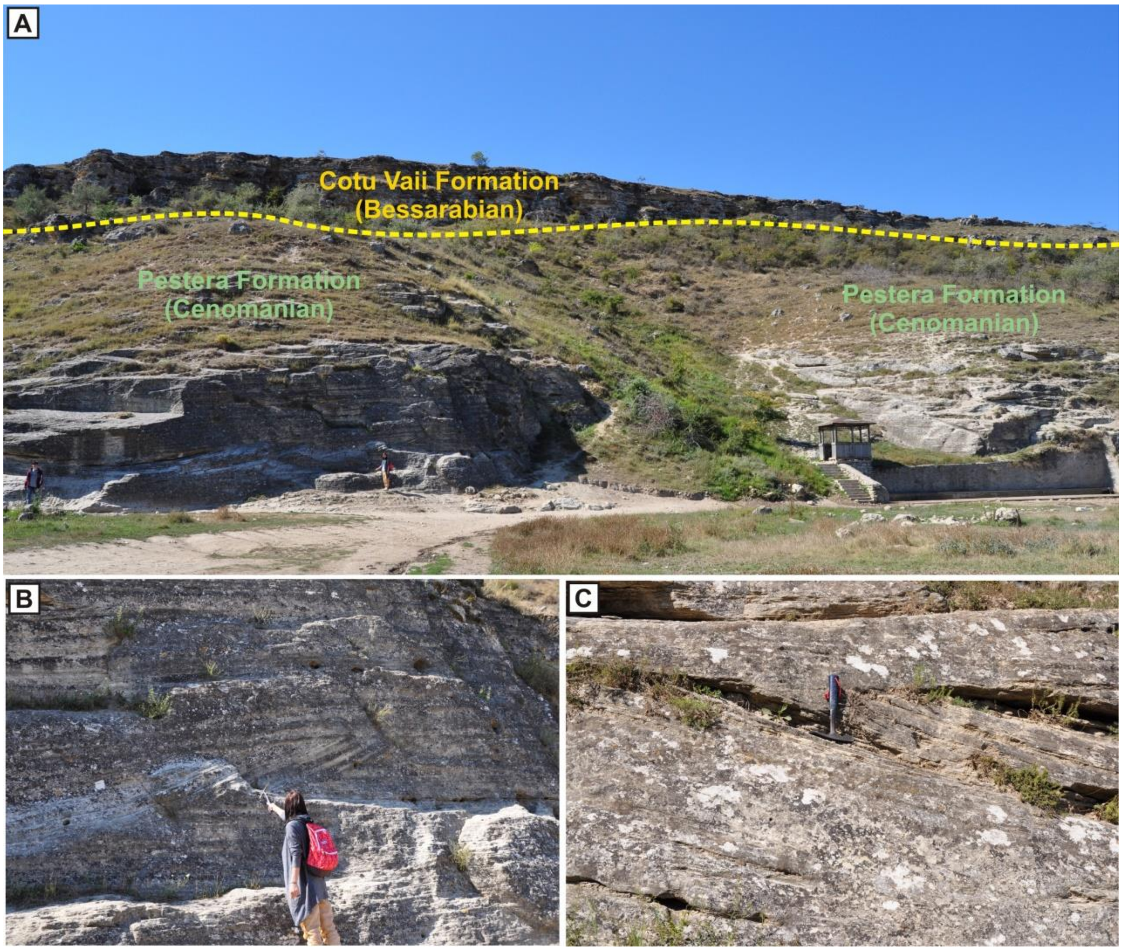

Fig. 7.2. A – Canaraua Mare Valley: deposits of the Peştera Formation (coarse sandstones, glauconitic calcareous sandstones) are trangressively covered by the Cotu Văii Formation (bioclastic limestones); **B, C-** large scale cross-bedded siliclastic deposits of the Peştera Formation.

Location: In Petroşani Village, at the southern exit of the village, N 44°0'32.6232"; E 28°3'14.3424". This is a protected area of national interest which corresponds to the IUCN III category (geological), extended on around 4.8 ha, and situated on the administrative territory of Deleni commune, at 0.5 km south of Petroşani Village and on both sides of Urluia Village. The protection refers to the geological units that crop out locally, that is, the Upper Cretaceous Peştera Formation (Cenomanian) that is trangressively overlain by the Middle Miocene, Sarmatian (middle, Bessarabian substage) Cotu Văii Formation.

Description: The lower part of the succession is composed of lower Cenomanian glauconitic sandstones and conglomerates. These deposits start with a poorly sorted basal conglomerate, followed by sands or quartzose coarse sandstones with parallel and cross-stratification. Toward the upper part of the Cenomanian succession, quartz- and glauconitic-rich calcareous sandstones are present. Bioturbations such as *Planolites* and *Thalassinoides* occur frequently.

The early Cenomanian age of the Peştera Formation was assigned based on its macrofauna, mainly ammonites and inoceramids, and microfaunas, such as foraminifers (Chiriac, 1981; Avram et al., 1988, 1993; Ion & Szasz, 1994). Accordingly, the Peştera Formation belongs to the *Mantelliceras mantelli* Ammonite Zone and contains index species foraminifers like *Rotalipora appeninica* and *R. globotruncanoides*.

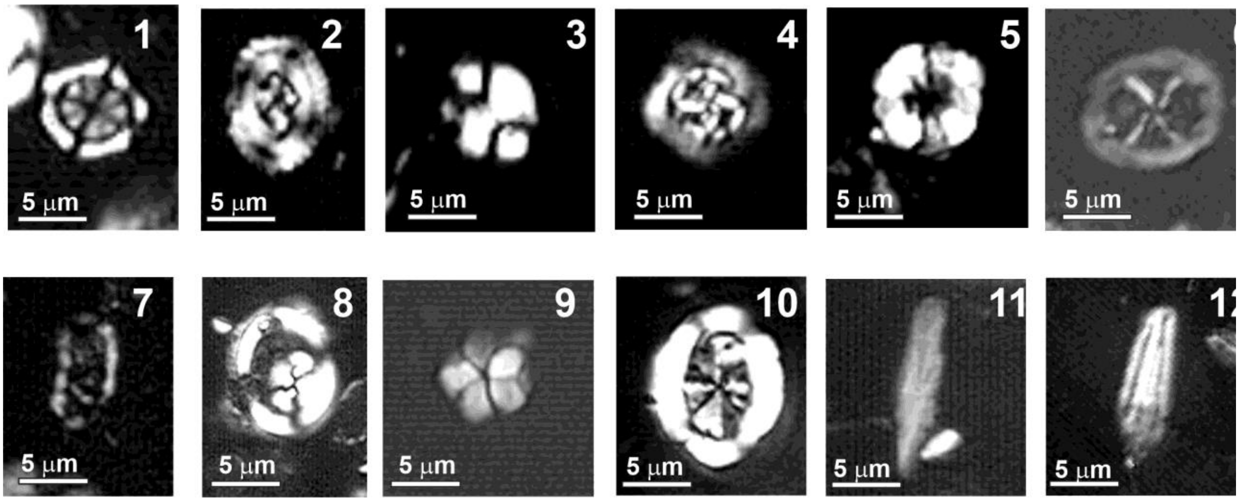

Fig. 7.3. – Microphotographs of calcareous nannofossils identified in the Limestone Walls from Petroşani, taken at LM (light microscope), N+ (crossed-nicols), scale bar in microns. **1**- *Corollithion kennedyi* Crux, 1981; **2** - *Helenea chiastia* Worsley, 1971; **3** - *Calculites percernis* Jeremiah, 1996; **4** - *Prediscosphaera cretacea* (Arkhangelsky, 1912) Gartner, 1968; **5** - *Eprolithus floralis* (Stradner, 1962) Stover, 1966; **6** - *Chiastozygus litterarius* (Górka, 1957) Manivit, 1971; **7** - *Rhagodiscus angustus* (Stradner, 1963) Reinhardt, 1971; **8** - *Manivitella pemmatoidea* (Deflandre *in* Manivit, 1965) Thierstein, 1971, inside *Watznaueria barnesiae* (Black *in* Black & Barnes, 1959) Perch-Nielsen, 1968; **9** - *Braarudosphaera africana* Stradner, 1961 ; **10** - *Gartnerago segmentatum* (Stover, 1966) Thierstein, 1974; **11** - *Lithraphidites acutus* Verbeek & Manivit *in* Manivit et al., 1977; **12** - *Lithraphidites alatus* Thierstein *in* Roth & Thierstein, 1972.

The clays interbedded with the sandstones yielded calcareous nannofossil assemblages containing several long-ranging species, but also taxa significant for biostratigraphy, such as *Corollithion kennedyi*, *Gartnerago segmentatum* and *Lithraphidites acutus* that have their FO (first occurrence) in the early Cenomanian, along with *Helenea chiastia* (LO - last occurrence within the Cenomanian-Turonian boundary), and taxa restricted to the Albian-Cenomanian interval (e.g., *Lithraphidites alatus* and *Braarudosphaera africana*; Fig. 7.3.). Based on these findings, the calcareous nannofossils indicate an early Cenomanian age.

The middle Sarmatian (Bessarabian) deposits are composed by shelly limestones, calcarenites and calcareous sandstones with thin clay intercalations. The sediments are rich in mollusk shells, especially bivalves such as *Sarmatimactra vitaliana*, *S. eichwaldi*, *Tapes tricuspis*, and *Obsoletiforma* spp.

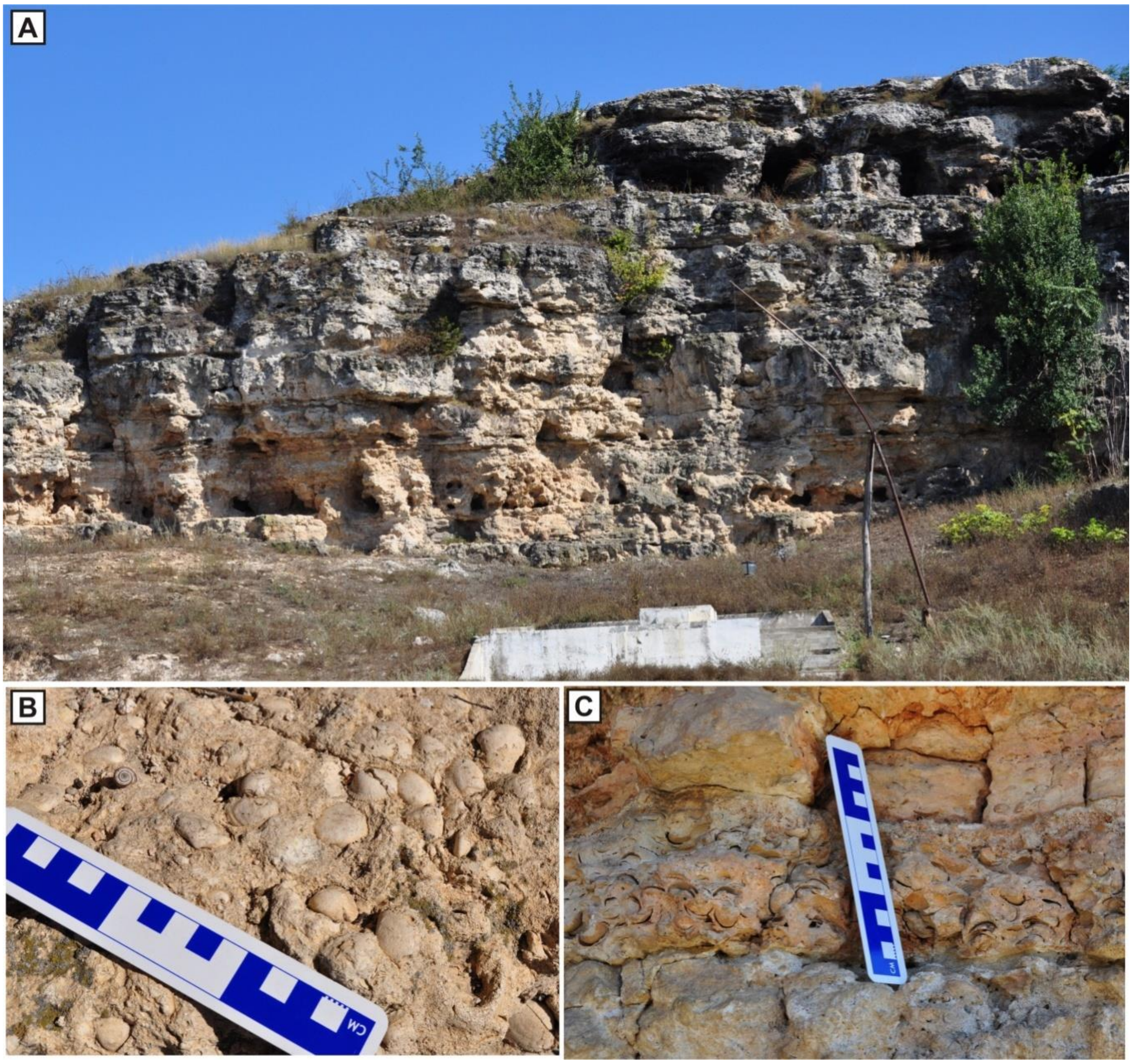

Fig. 7.4. A-C. Middle Sarmatian (Bessarabian) deposits of the Cotu Văii Formation cropping out in Petroşani Village, Canaraua Fetii Valley.

Stop 8. Şipotele Section

Marius Stoica, Lazăr Iuliana

Stratigraphy: Cernavodă Formation, Adamclisi Member (Valanginian); Cochirleni Formation (Albian); Cotu Văii Formation (Sarmatian).

Location: At the southern exit of Şipote Village (44° 2'26.13"N; 27°57'44.27"E)

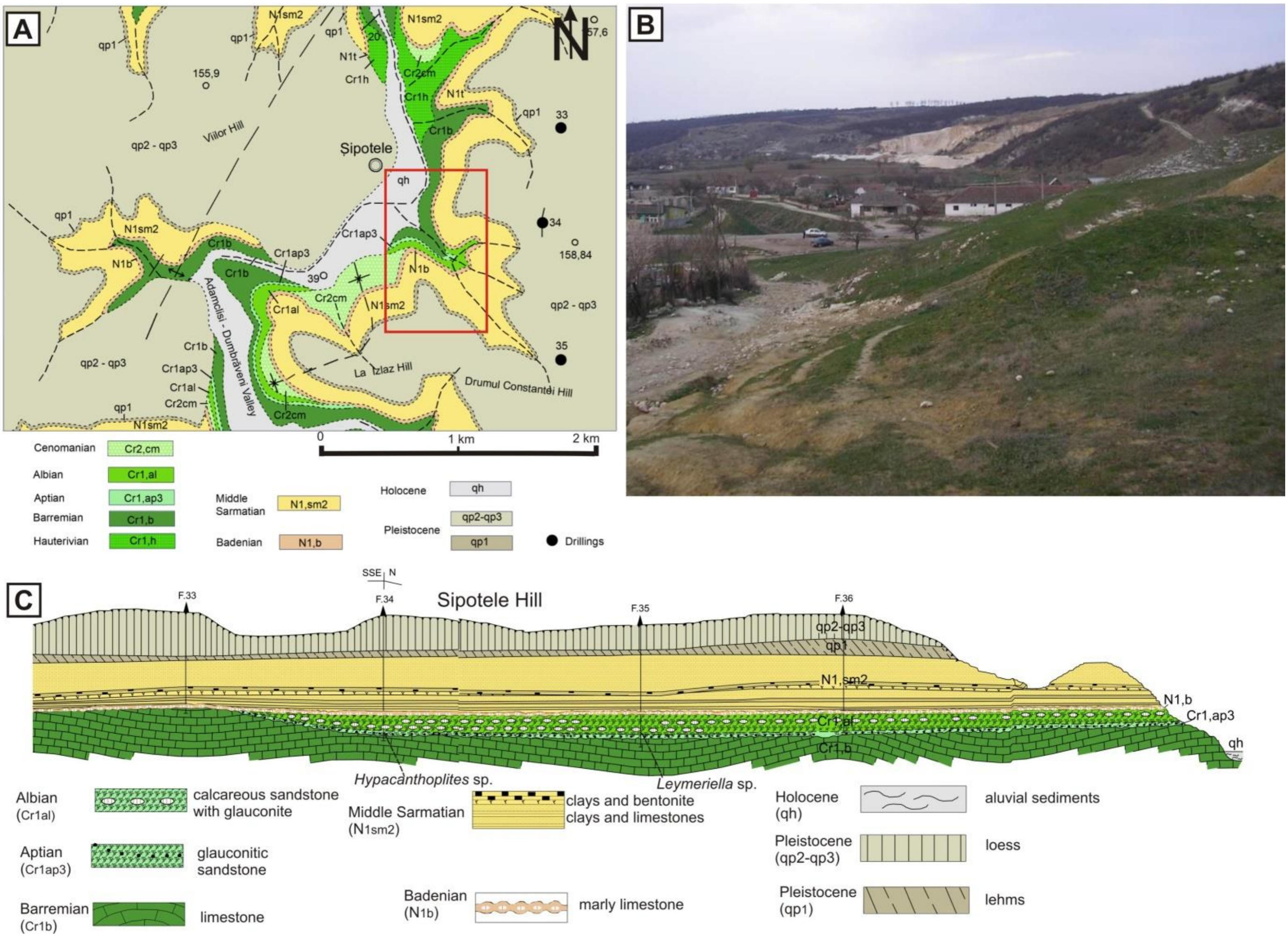

Fig. 8.1. A - Location of the visited section on the geological map of Şipotele area; **B-** Şipotele section with a large quarry in Cretaceous deposits; C - geological cross-section in Şipotele area (A and C modified from Chiriac, 1981).

Description: On the right slope of Ghiolpunar Valley, close to a spring, Cretaceous limestones, glauconitic sandstones and microconglomerates are transgressively overlain by 3-4 meters of calcareous sandstones and tuffitic interbeds, barren in fossils but assigned to the lower Sarmatian. These, in turn, are covered by a 15 m thick succession of sandstones, limestones, sands, marls, clays and diatomites (Popescu in Andreescu *et al.*, 1996). At some levels, these sediments are very rich in fossils such as mollusks, foraminifers, ostracods, diatoms (in the upper part). In the lower levels of the Sarmatian calcareous sandstones and limestones, the following taxa were recognized: *Sarmatiella eichwaldi*, *S. andrussovi*, *S.*

vitaliana, Ervillia dissita, Tapes trcuspis, Plicatiforma plicata, Obsoletiforma obsoleta, O. vindobonense, Pirenella disjuncta, Duplicata opinabile etc, considered as indicative for the Late Volhynian (Early Sarmatian). In the upper part of this section, the Bessarabian and Chersonian time-intervals are also indicated by the fossil assemblages.

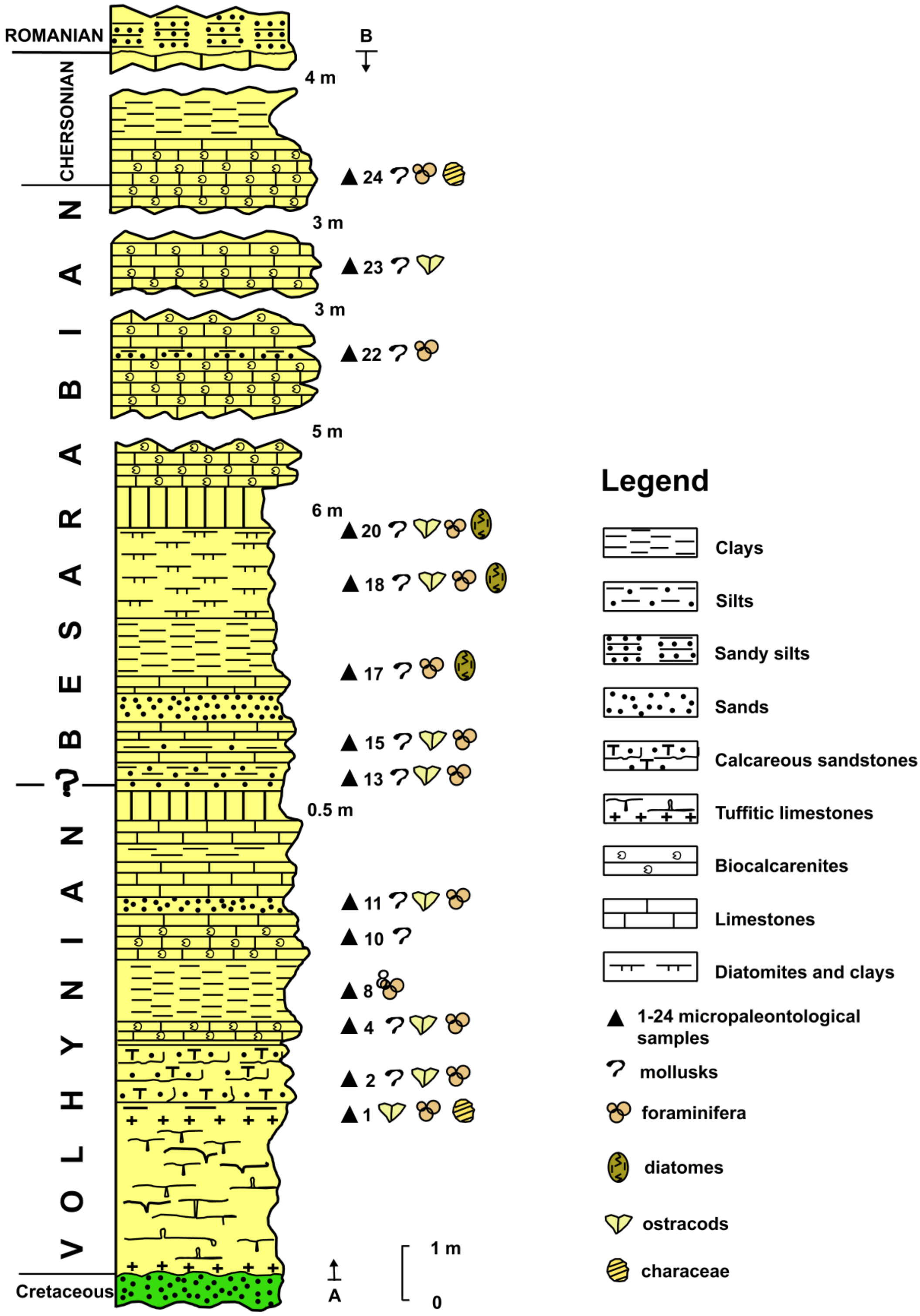

Fig. 8.2. Litostratigraphic log of the Sarmatian deposits, Şipotele section (modified from Popescu in Andreescu *et al*., 1996)

Stop 9. Lespezi Quarry

Marius Stoica, Iuliana Lazăr

Stratigraphy: Lespezi Formation, Eocene (Late Ypresian)

Location: 1.5 km NE from Lespezi Village (44° 1'58.33''N; 27°50'31.51''E).

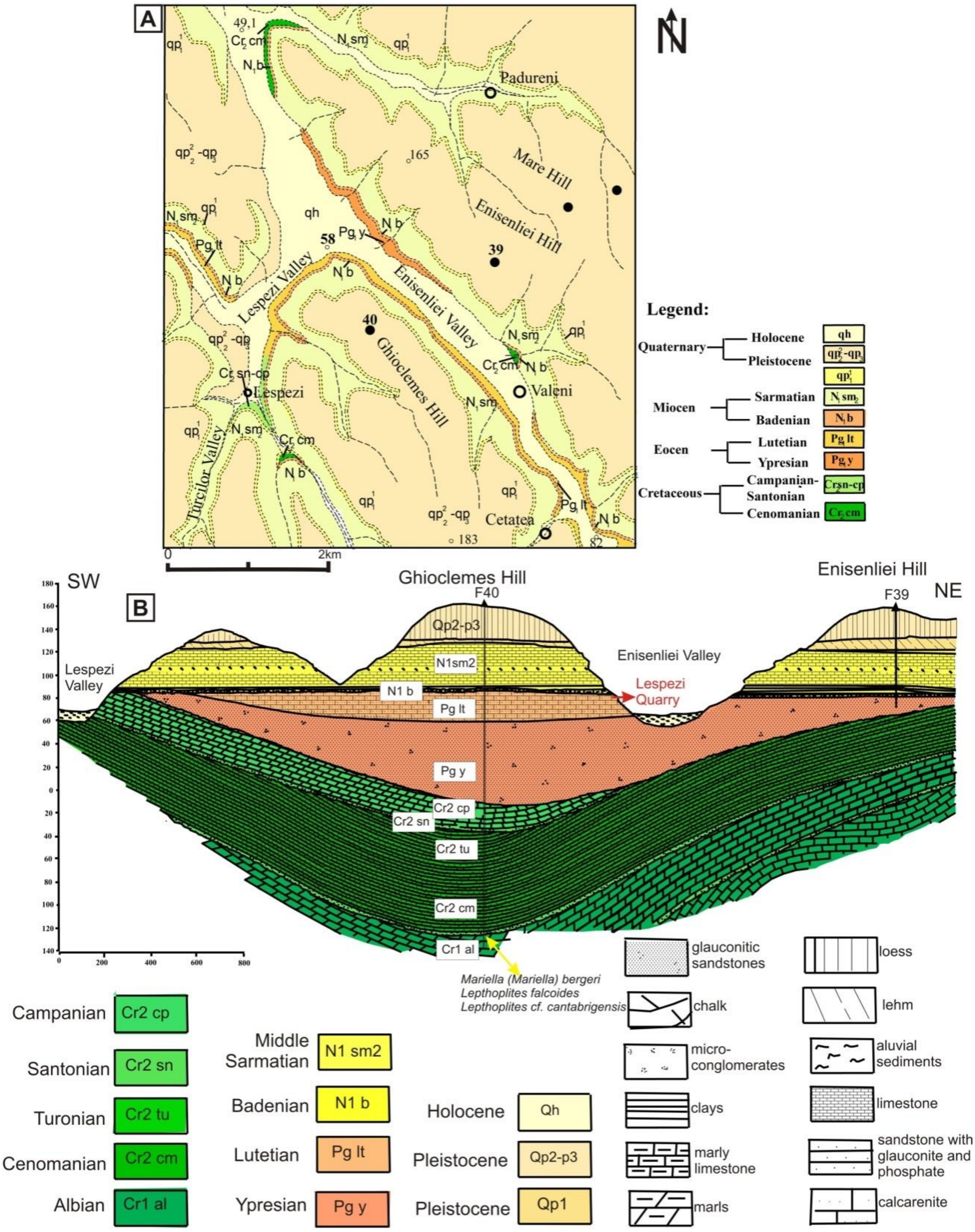

Fig. 9.1. A - Location of the Lespezi Quarry on the geological map of the Lespezi - Văleni area; **B -** geological cross-section in Lespezi area (modified from Chiriac, 1981).

Description: At the northern end of the Ghioclemes Hill, a small quarry exposes the middle lithostratigraphic unit of the Eocene succession in Southern Dobrogea, namely the Lespezi Formation. This formation crops out in the quarry on a front of about 8-9 meters thick and 20 meters long. The succession is composed of massive biocalcarenites (up to 30-40% siliciclastic grains) (Andreescu *et al.,* 1996). The rocks are generally soft, light-grey; in the upper part, chert nodules and vein-like black amorphous silicates occur. Their late Ypresian age was documented by a rich *Nummulites* assemblage: *Nummulites rotularis, N. irregularis, N. pratti*, *N. distans* (Bombiţă, 1987). The calcarenites had been excavated in this quarry for centuries. Almost 20% of the ancient citadels of the 4th century were built using stones from this quarry. These citadels are still visible on the northern slope of Ghioclemes Hill. More recently, in the 19th and 20th centuries, the same rocks were used for stone frames of gates and windows, and for casing of wells. The Eocene sediments are covered by greenish massive silty clays of Konkian age.

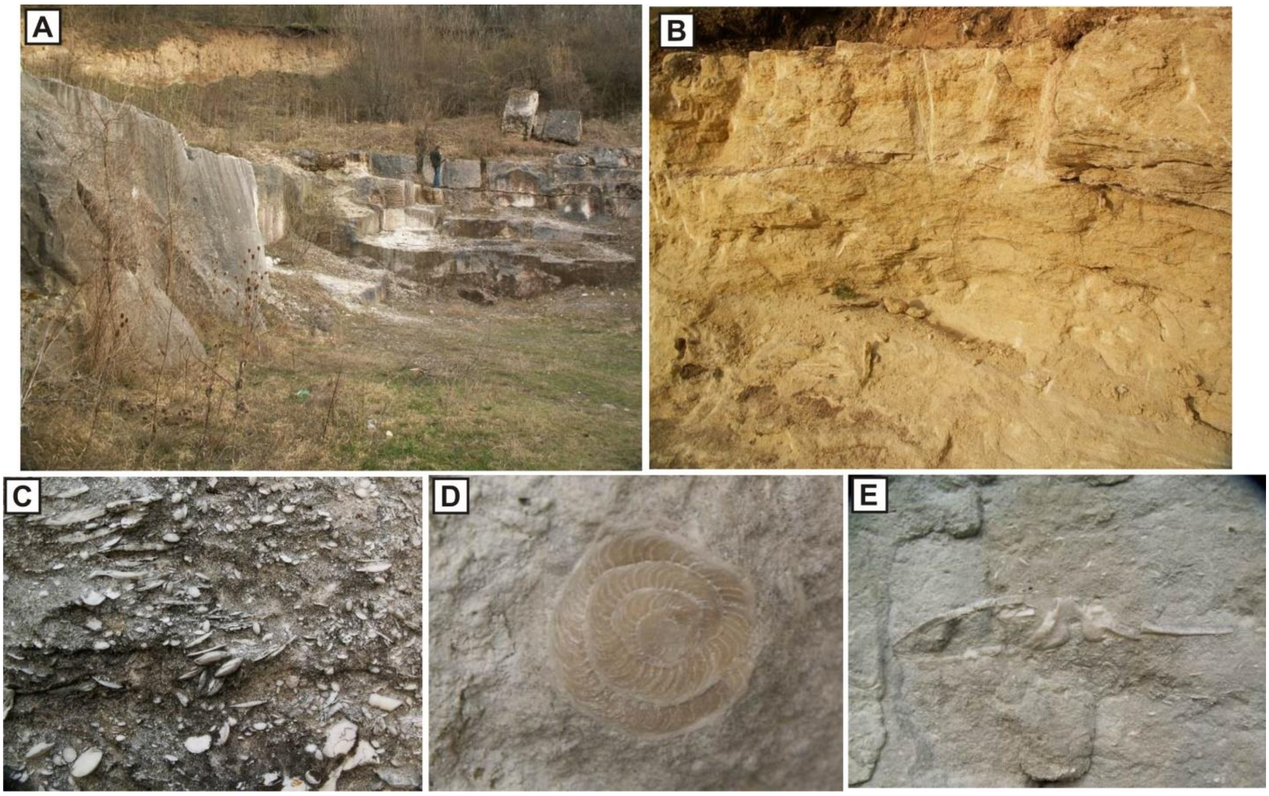

Fig. 9.2. A, B - Eocene- Late Ypresian biocalcarenites (Lespezi Formation), cropping out in Lespezi Quarry; **C -** biocalcarenites rich in *Nummulites* species; **D** - *Nummulites rotularis*; **E** - echinoids.

Stop 10. Peştera Quarry and La Porcărie section *Conulus* Lagerstätte

Lazăr Iuliana, Marius Stoica, Jaume Gallemí

Stratigraphy: Peştera Formation (Cenomanian – lower Turonian, in Peştera area), Seimeni Formation (Badenian), Cotu Văii Formation (Sarmatian, Bessarabian).

Location: Peştera Quarry is located at the northern exit of Peştera Village (44°11'29.63"N; 28° 7'34.99"E).

Description:

The base of the Peştera quarry section is actually exposed in another outcrop located 1 km toward south-east from the quarry, on the right slope of the Peştera River (44°10'51.37"N; 28° 8'7.84"E). Here, the Cenomanian deposits overlie the upper Aptian-lower Albian Cochirleni Formation represented by fossil-rich calcareous or glauconitic sandstones. The Peştera Quarry is located on the right slope of Peștera Valley, close to Peştera Village; here Cenomanian – lower Turonian glauconitic sandstones and conglomerates are exposed, unconformably covered by Badenian and Sarmatian deposits.

The walls of the quarry (almost 15-30 meters high) expose mainly the coarse unit of the Peştera Formation, represented by basal quartzose-phosphatic conglomerates and microconglomerates, as well as sands or quartzouse sandstones with glauconite and phosphatized pebble intercalations that display low-angle to tabular, planar parallel or cross-concave-lamination.

The age of the basal part of Peştera Formation was considered by Avram et al. (1988) and Chiriac (1981) as Cenomanian, based on correlation of this member with other sections from the area that contain marine fossil faunas. However, Gallemi *et al.* (2011, 2013) proposed the extension of the stratigraphic interval covered by Peştera Formation to the lower and middle Turonian, based on echinoids [*Conulus subrotundus* Mantell, 1822, *Discoides minimus* (Desor, 1842)] and inoceramids discovered in Peştera Quarry. Recently, Trif and Codrea (2022) described numerous taxa of fish teeth (Chondrichthyes and Actinopterygii) from the lower units of these deposits.

The Konkian deposits (Seimeni Formation) transgressively overlie the Cretaceous ones, and are represented by thin-bedded greenish clays and gravels.

The Sarmatian sequence (Cotu Văii Formation) starts with massive greenish clays covered by shelly and bioclastic limestones, calcarenites and calcareous sandstones with thin clay or silt intercalations.

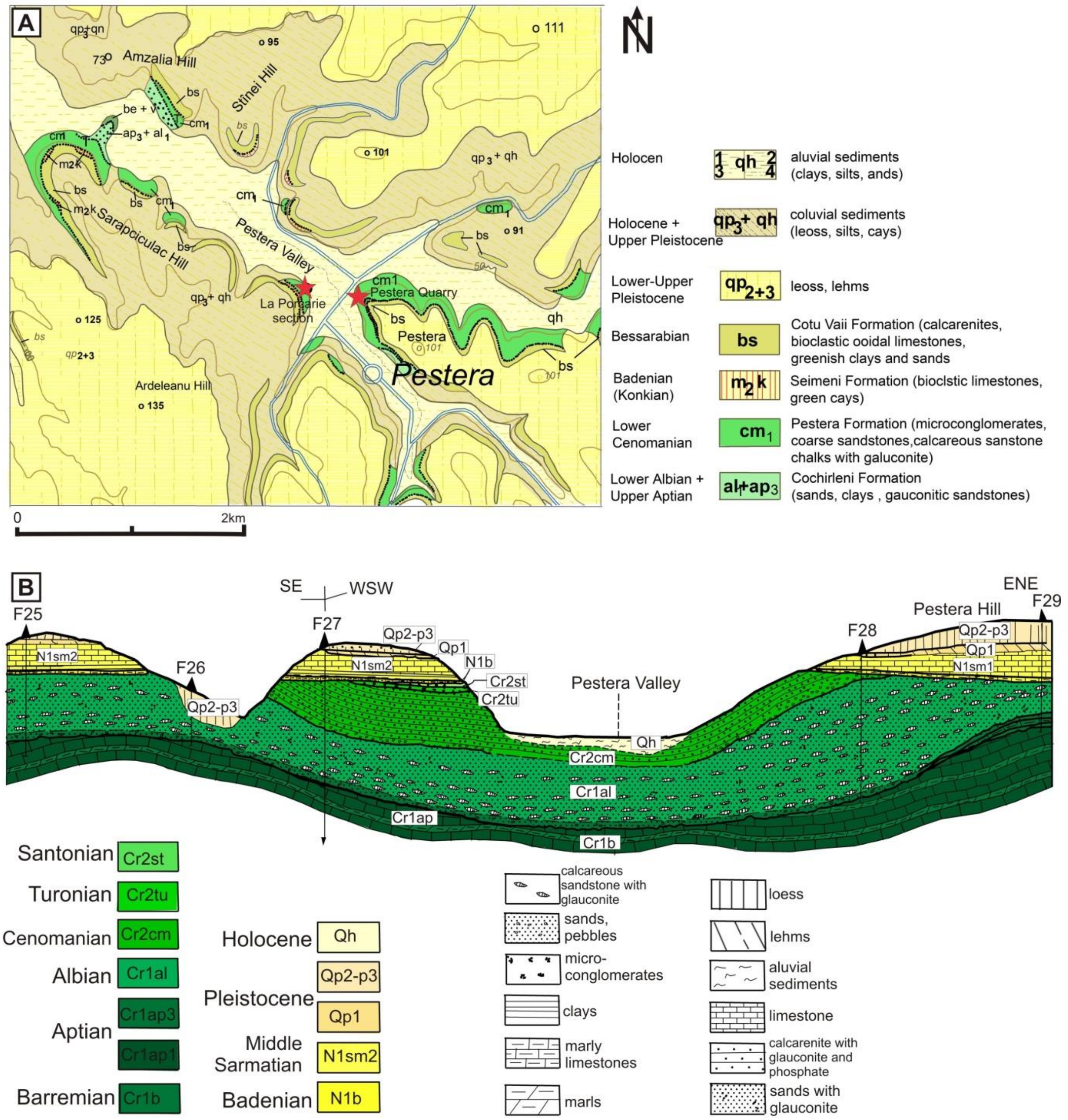

Fig. 10.1. A- Geological map of the Peştera area; **B** - Geological cross-section in the Peştera area (modified from Chiriac, 1981).

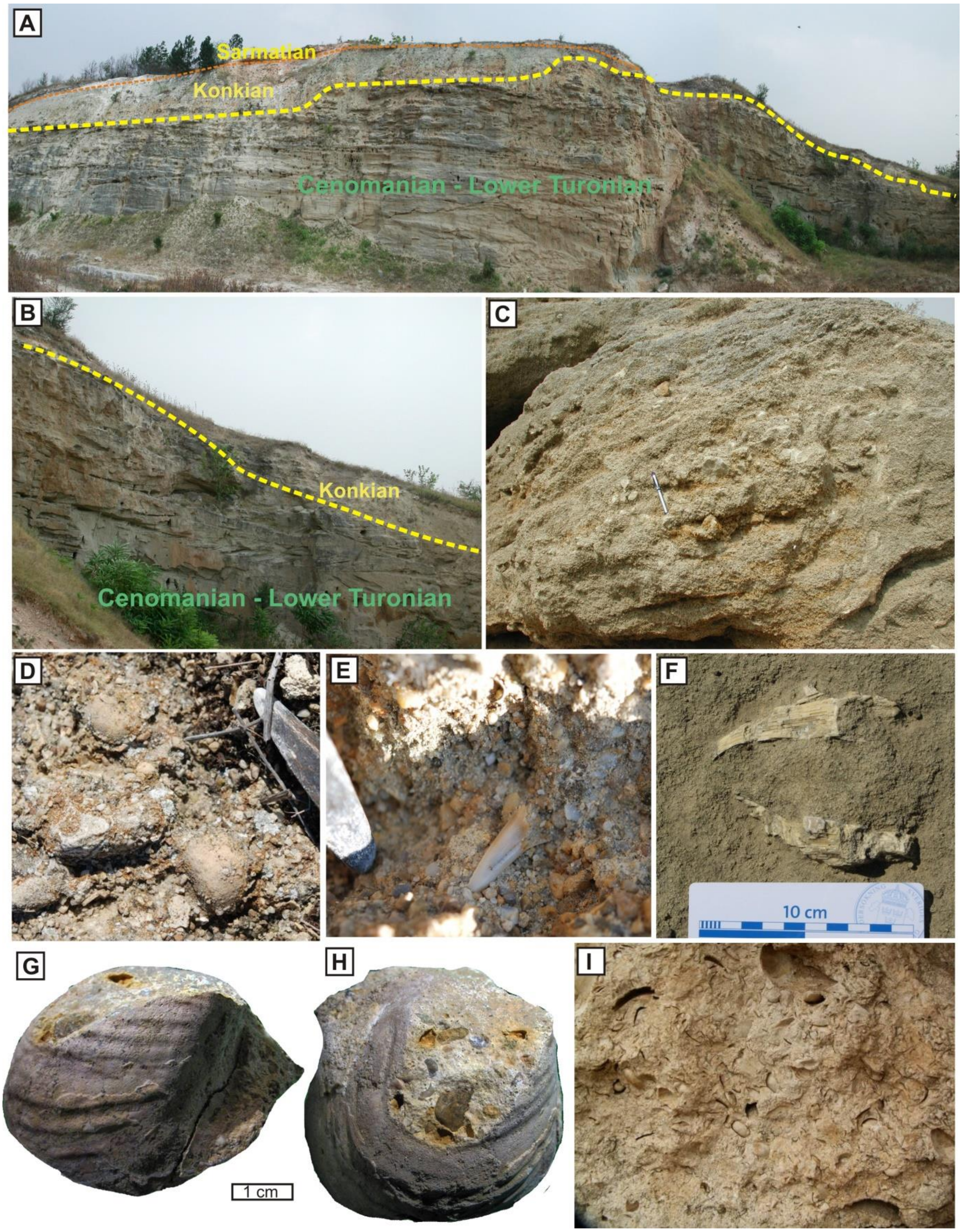

Fig. 10. 2. Peştera Quarry: **A-B** - outcrop views in the quarry; **C** – Lower Cenomanian coarse sandstones; **D** – echinoids fossils (*Conulus*) and E – shark tooth in Lower Cenomanian sandstones; F – bivalve shells from Family Radiolitidae; **G, H** – *Cremnoceramus deformis erectus* (Meek, 1877); **I** – bioclastic limestones rich in bivalves (*Mactra*) and gastropods, Cotu Văii Formation (Sarmatian, Bessarabian).

The La Porcărie section is located at 800 meters west from the Peştera Quarry, on the left slope of Peştera Valley, near to the road intersection of DN 222 with a secondary local road (44°11’24,732”N, 28°06’59,480”E).

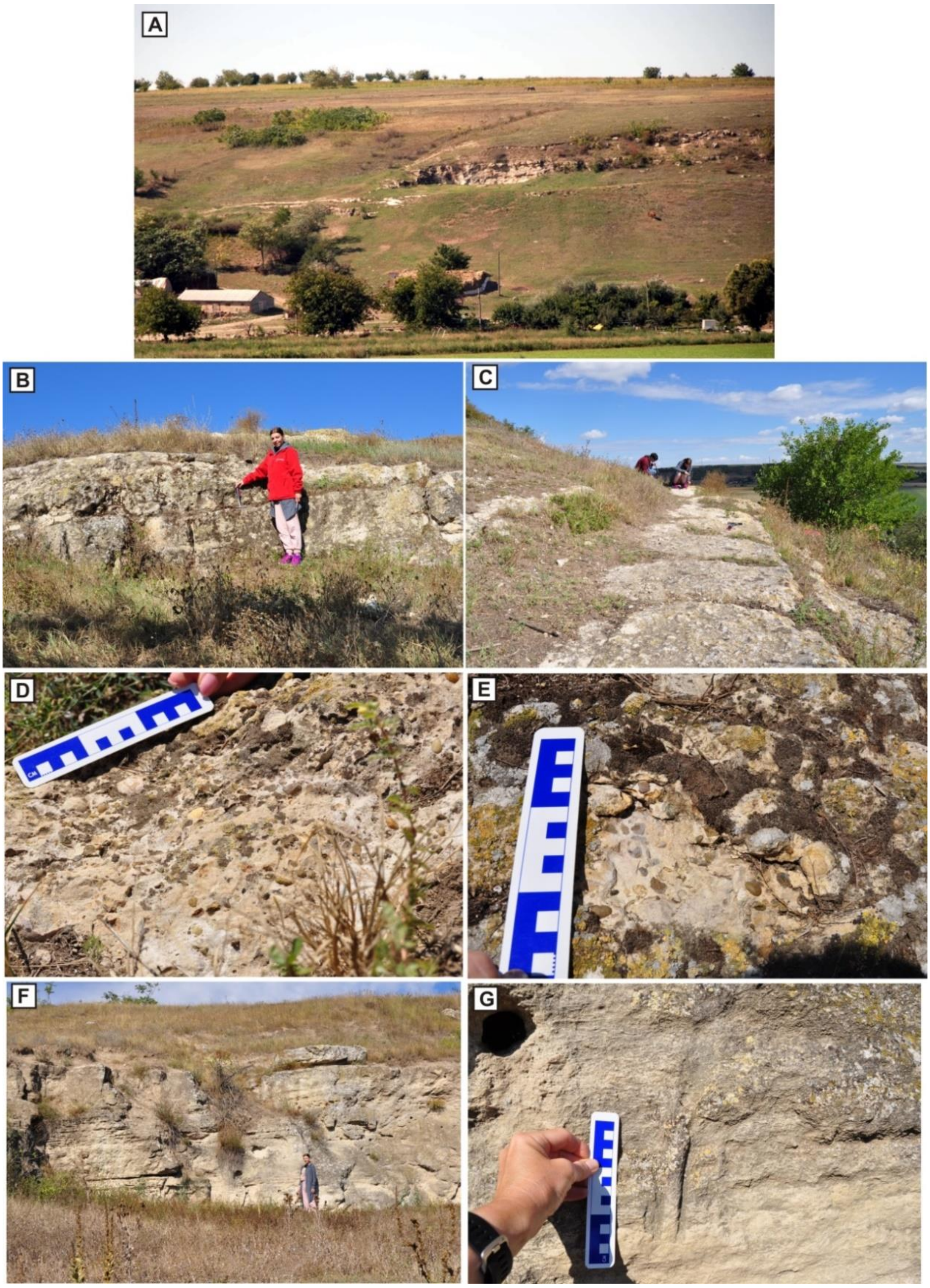

Fig. 10.3. La Porcărie section: **A, B** – outcrop view of the lower part of the Turonian deposits (organodetrital limestone, with intraclasts, quartz grains (sand), abundant phosphatized clasts and bioclasts); **C –E** - the surface of the *Conulus* Lagerstätte bed; **F, G** - coarse calcareous sandstones with bioturbations in the upper part of the section.

The stratigraphic succession from La Porcărie sections is remarkable due to a bed containing high concentration of echinoids from the genus *Conulus*. This section was described for the first time by Dragomir (1990). The succession is only 7 meters thick and is composed of basal calcareous sandstones, followed by mixed rock types such as organodetrital limestones with a variable amount of admixture of quartz grains (sand) and phosphatized lithoclasts containing inoceramid bioclasts, rare echinoids and brachiopods [*Gibbithyris semiglobosa* (Sowerby, 1813) and *Praelongithyris sp.*]

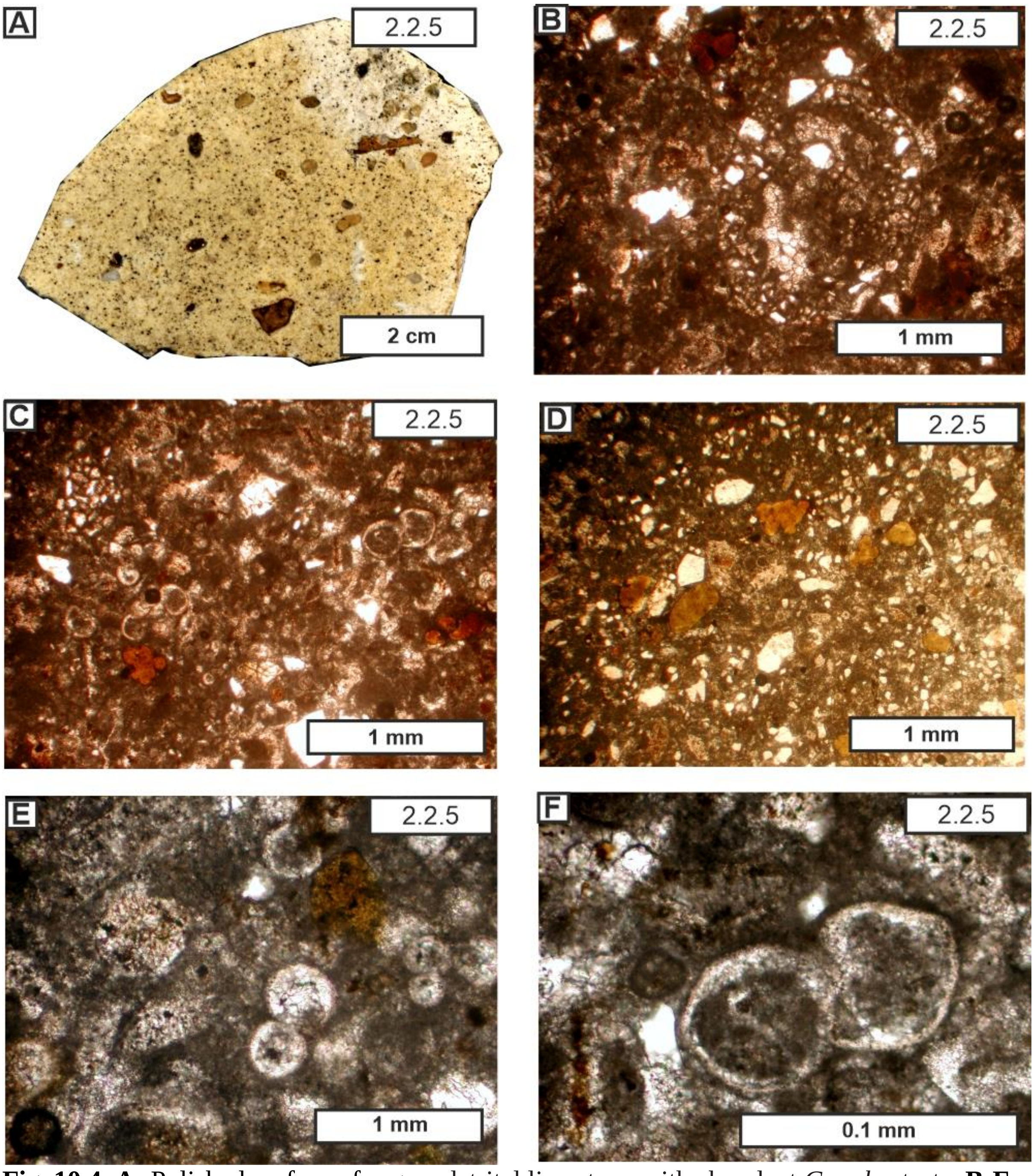

Fig. 10.4. A- Polished surface of organodetrital limestone with abundant *Conulus* tests; **B-F -** bioclastic-foraminiferal-calcisphere wackestone to packstone with quartz grains, glauconite, phosphatized grains and bioclasts.

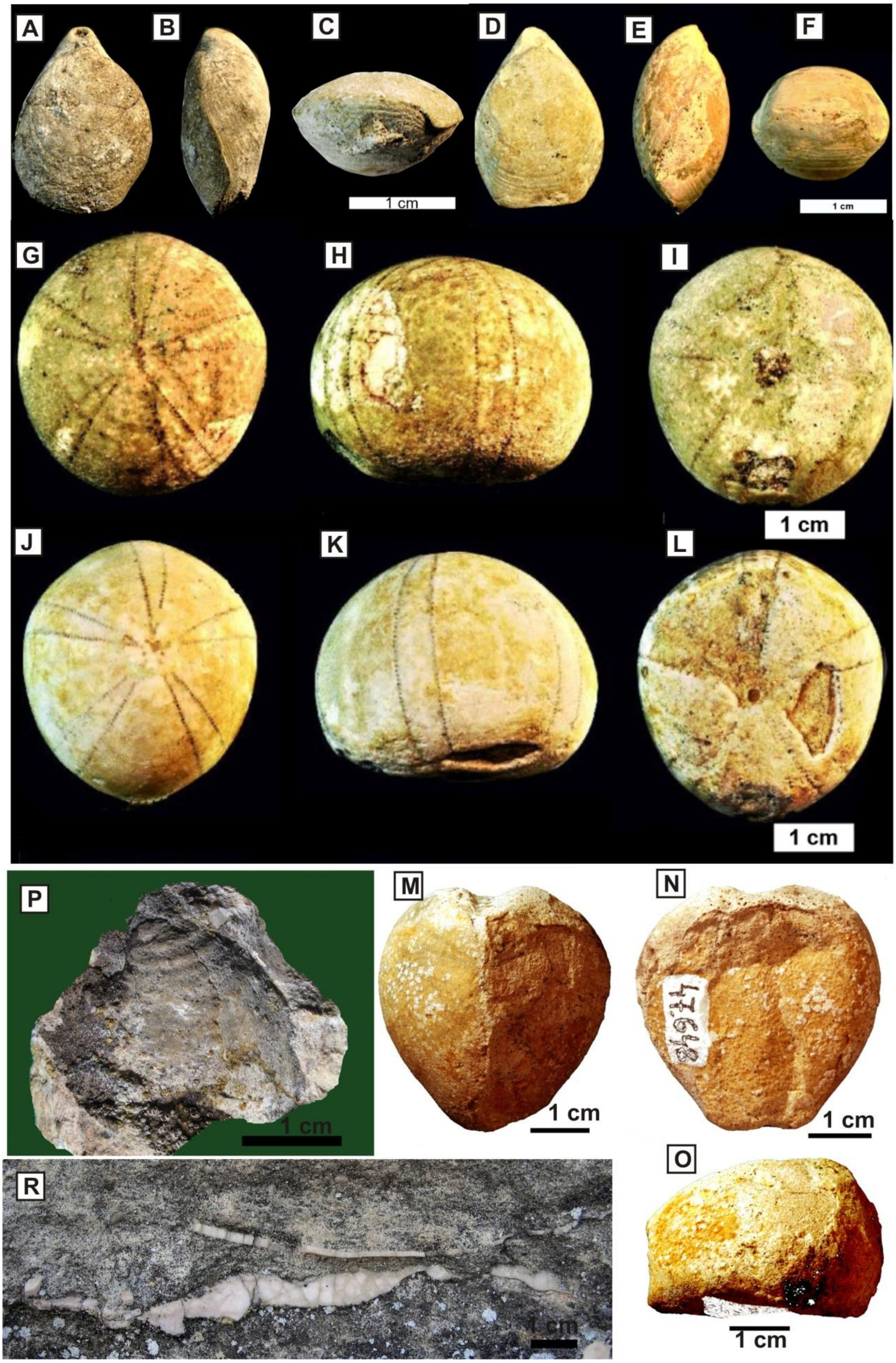

Fig. 10.5. Macrofossils from La Porcărie section: **A-C -** *Gibbithyris semiglobosa* (Sowerby 1813); **DF -** *Praelongithyris* sp.; **G-L -** *Conulus subrotundus* Mantell, 1822; I - *Inoceramus* cf. *apicalis* (Woods, 1912); J - *Inoceramus* cf. c*uvieri* Sowerby, 1814; **K, L, M -** *Protocardiaster cotteauanus* (d'Orbigny, 1855).

This bed is followed by 1.2 meters of medium to poorly cemented, almost white organodetrital limestone, containing irregular intraclasts of limestone and a high amount of quartz grains (sand), abundant phosphatized clasts (quartz grains and bioclasts); toward the top of this bed (10-20 cm) abundant echinoids of the species *Conulus subrotundus* Mantell, 1822 occur, together with rare specimens of *Discoides minimus* (Desor, 1842) and *Protocardiaster cotteauanus* (d'Orbigny, 1855). These taxa are indicative for the middle-upper Turonian interval (Gallemí et al., 2011, 2013).

Tens of *Conulus* specimens can be observed on the bed surface forming clusters of three to ten specimens each, and the preliminary palaeontological study of the collected material allows to consider this assemblage as monospecific, formed by the representatives of the species *Conulus subrotundus.* The echinoid specimens are variably oriented within the bed; most of the specimens are lying in normal positions or inclined on the side, while very few are inverted. The rock infilling the echinoid tests is represented by bioclastic-foraminiferal-calcisphere wackestone to packstone with common quartz grains (0.25-1 mm) and glauconite, phosphatised grains and clasts (5 -10 mm), and inoceramid shell fragments. All these features suggest that the bed with *Conulus* from La Porcărie section could be considered as a *Conulus* Lagerstätte, an accumulation of marine lag sediments with concentrations of autochthonous and parauthochtonus echinoid fossils within an environment with reduced rate of sedimentation, and affected periodically by erosional events. Similar *Conulus subrotundus* Lagerstätte was described by Olszewska-Nejbert (2005) from the Turonian from Southern Poland.

The upper part of the section is represented by coarse calcareous sandstones with numerous bioturbations and inoceramids [*Inoceramus* cf. *apicalis* (Woods, 1912), *Inoceramus* cf. *cuvieri* Sowerby, 1814] indicating the middle – upper Turonian interval.

Third day: 18 September 2023

Stop 11. Piatra geosite – Ediacaran turbidites with sedimentary and enigmatic (possibly biogenic) structures

Antoneta Seghedi

Stratigraphy: Histria Formation (Upper Neoproterozoic, Ediacaran)

Location: Small left tributary of Taşaul valley, north ofPiatra (44°24'57.22"N, 28°34'11.24"E).

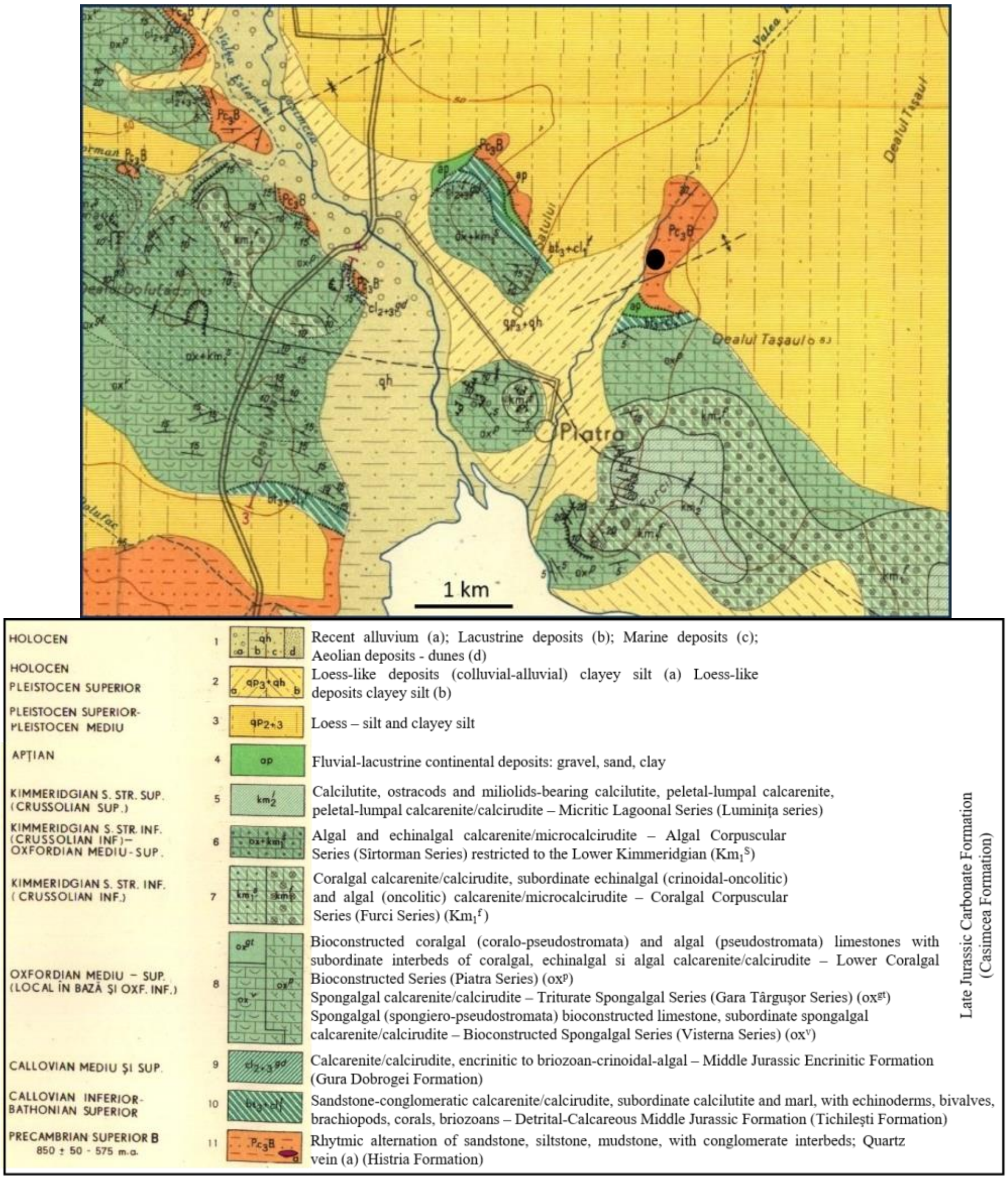

Fig. 11.1. Excerpt from the geological map, scale 1:50000 (Drăgănescu et al., 1979), showing the Ediacaran basement and its Jurassic cover in the eastern part of the Casimcea syncline. The legend is slightly modified. The black dot in the Ediacaran (figured as Pc_3B on the map) represents the Piatra geosite.

Description: Over the largest part of its outcrop area, the basement of Central Dobrogea (East Moesian Platform) is represented by a thick turbidite succession (Mirăuţă, 1964, 1965) known as "the Greenschist series". As this name reflects only the colour of rocks, and not their metamorphic grade, the succession was renamed as the Histria Formation (Seghedi, Oaie, in Grădinaru et al., 1995). The Late Neoproterozoic age of the Histria Formation is demonstrated based on a scarce Ediacara-type fauna (Oaie, 1992, 1999, 2010; Oaie *et al*., 2005, 2012) and detrital zircon ages (Żelaźniewicz *et al*., 2009; Balintoni et al., 2011). In Central Dobrogea, the platform cover preserved on top of these turbidites is represented by several outcrops of Jurassic deposits, the largest part of these forming the Casimcea syncline (Drăgănescu et al., 1979). In places, at the base of the Middle Jurassic calcarenites, remnants of a pre-Bathonian palaeoweathering crust were found (Rădan, 1994, 1999; Seghedi *et al*., 1999). On the previous geological map of the area (Drăgănescu et al., 1979), these were erroneously ascribed to the Aptian. Sedimentary structures are a common feature of the Histria Formation over its entire outcrop area. However, there are two geosites where these structures are found *in situ* and are extremely spectacular. One of these geosites is located north of Piatra village, on the left bank of the Taşaul valley.

Fig. **11. 2.** Bed surface at Piatra with attenuated ripples overprinted by various current marks, along with some curved, enigmatic traces.

The Piatra geosite is remarkable due to the abundant primary sedimentary structures visible on well-exposed bed surfaces (Oaie, 1999; Oaie *et al*., 2012). The outcrops (Fig. 1) represent a succession of thinly bedded distal turbidites (Tcde Bouma divisions), dipping 10-20^{o} south. The large bedding surfaces, most of them showing attenuated current ripples (Fig.10.2.), display various sedimentary structures, both mechanical and possibly biogenic.

Current and chevron marks are the most frequently observed (Oaie, 1999), but enigmatic traces, irregular or curved, also occur (Figs. 10.3-10.5). An *Aspidella*-type trace fossil (Fig. 10.6) was also observed (Seghedi *et al.*, 2018).

Fig. 11.3. Parallel chevron marks, arrow indicating paleoflow direction.

Fig. 11.4. Unidentified, curved traces at Piatra.

Fig. 11.5. Enigmatic trace which might be biogenic.

Fig. 11.6. Curent marks and a concentric trace reminiscent of the *Aspidella* Ediacaran trace fossil.

Stop 12. Piatra limestone Quarry

Iuliana Lazăr, *Bogusław Kołodziej*

Stratigraphy: Casimcea Formation: Piatra Member (middle - upper Oxfordian)

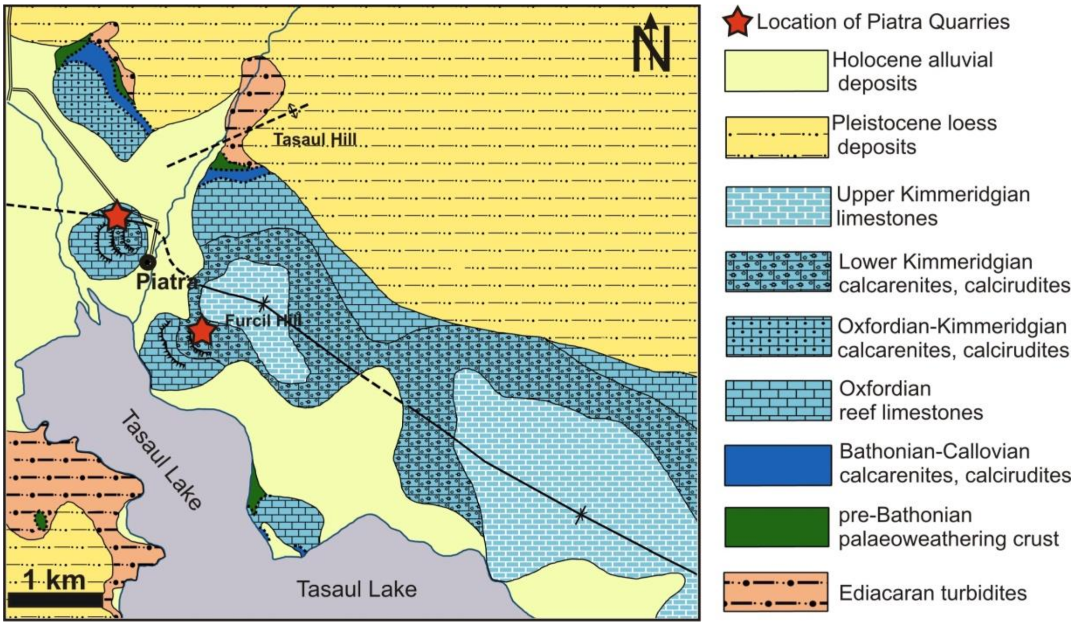

Fig. 12.1. Location of the Piatra quarries on the geological outline map of Central Dobrogea (based on Drăgănescu et al., 1979).

Location: eastern part of Central Dobrogea; two quarries located along the Sârtorman Valley and around Piatra locality, near Taşaul Lake (Furcil Hill quarry 44°24'21.62"N; 28°33'1.77"E).

Description: The Piatra Member consists of thick to medium-bedded sequences (20–30 m total thickness) and represents the easternmost occurrence of the carbonate ramp in Central Dobrogea. This member consists of coral limestone sequences (coral floatstone to coral framestone) and bioclastic limestones (mollusk-coral floatstone/rudstone/bindstone and ooidal bioclastic grainstone/rudstone).

The coral biostromes are represented by fungiid boundstone-floatstones, interfingering with bioclastic packstones, lithoclastic-ooidal grainstones to rudstones and oncoidal wackestone with "*Bacinella–Lithocodium*" oncoids; these deposits accumulated on the middle part of the ramp (Herrmann 1996). Corals are represented by Microsolenidae (indicating a low-light environment), associated with microbial crusts, hydrozoans, sclerosponges (*Neuropora* sp.), calcareous sponges (*Peronidella* sp.), lithistid sponges (*Hyalotragos pezizoides*), large bivalves (*Velata*, *Chlamys*, *Aequipecten*, *Ctenostreon*, *Entolium*, *Opisoma*, *Diceras*), gastropods,

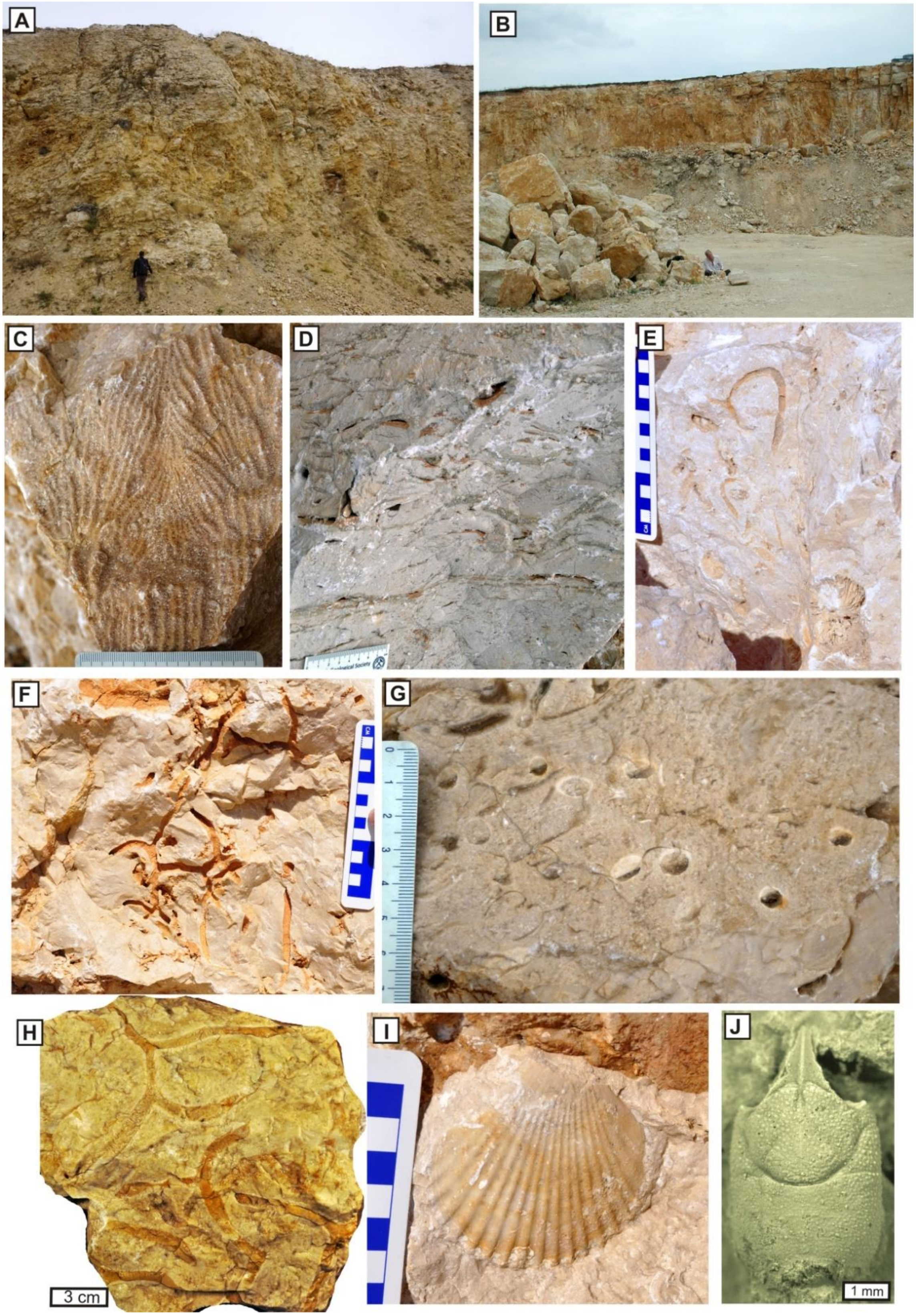

Fig.12.2. A, B - Exposure of the Oxfordian coral reef limestone in Piatra quarry from Furcil Hill**; C, D** - coral framestone (branching corals and microsolenids); **E-H -** *Macroterebella hoffmanni* burrows in fungiid boundstone-floatstone; **I**– *Chlamys textoria* bivalve in bioclastic packstone; **J** - *Cracensigillatus acutirostris* decapod crustacean from coral framestone (J from Schweitzer *et al.*, 2017).

brachiopods (terebratulids, rare rhynchonellids such as *Lacunosella trilobataeformis*), bryozoans, serpulids, crinoids, echinoids, rare ammonites, foraminifera represented by examples of Lituolidae, Miliolida, and Textulariidae (Bărbulescu 1971, 1974; Herrmann 1996), and decapod crustaceans (Franţescu, 2010; Schweitzer et al., 2017). Based on the presence of the ammonite *Discosphinctes* sp. and the brachiopod *Lacunosella trilobataeformis*, the Piatra Member corresponds to the middle-upper Oxfordian stratigraphic interval (cf. Bărbulescu, 1976; Bărbulescu in Dragastan et al., 1998).

Recently, Kołodziej *et al*. (in press.) described a new trace fossil as *Macroterebella hoffmanni* nov. igen., nov. isp. from these limestones. This new ichnotaxon is a tubular, branched, and winding burrow (5–14 mm in diameter) displaying a thick wall (0.8–2 mm) with a micropeloidal texture. The burrows contain in the walls abundant calcite pseudomorphs after dolomite. The burrow lumen resulted from burrowing by the tracemaker, most likely a polychaete worm of the family Terebellidae, while the wall is nonconstructional, and was microbially mediated. This new ichnospecies is extremely abundant in the Piatra reef limestone from Central Dobrogea, but was also identified by the same authors in Aptian limestones of the Rarău Mountains.

Stop 13. Dobrogei Gorges – Casimcea syncline

Stratigraphy: Casimcea Formation, Visterna Member, spectacular microbial-sponge ring-shape bioherms and biostromes (Oxfordian).

Location: Dobrogei Gorges along Visterna Valley, from the confluence of Visterna Valley with Casimcea Valley (44°30'26.75"N; 28°25'52.20"E) 1 km south of Cheia village, going to Târguşor (44°30'8.87"N; 28°25'16.21"E) along the axis of Casimcea syncline.

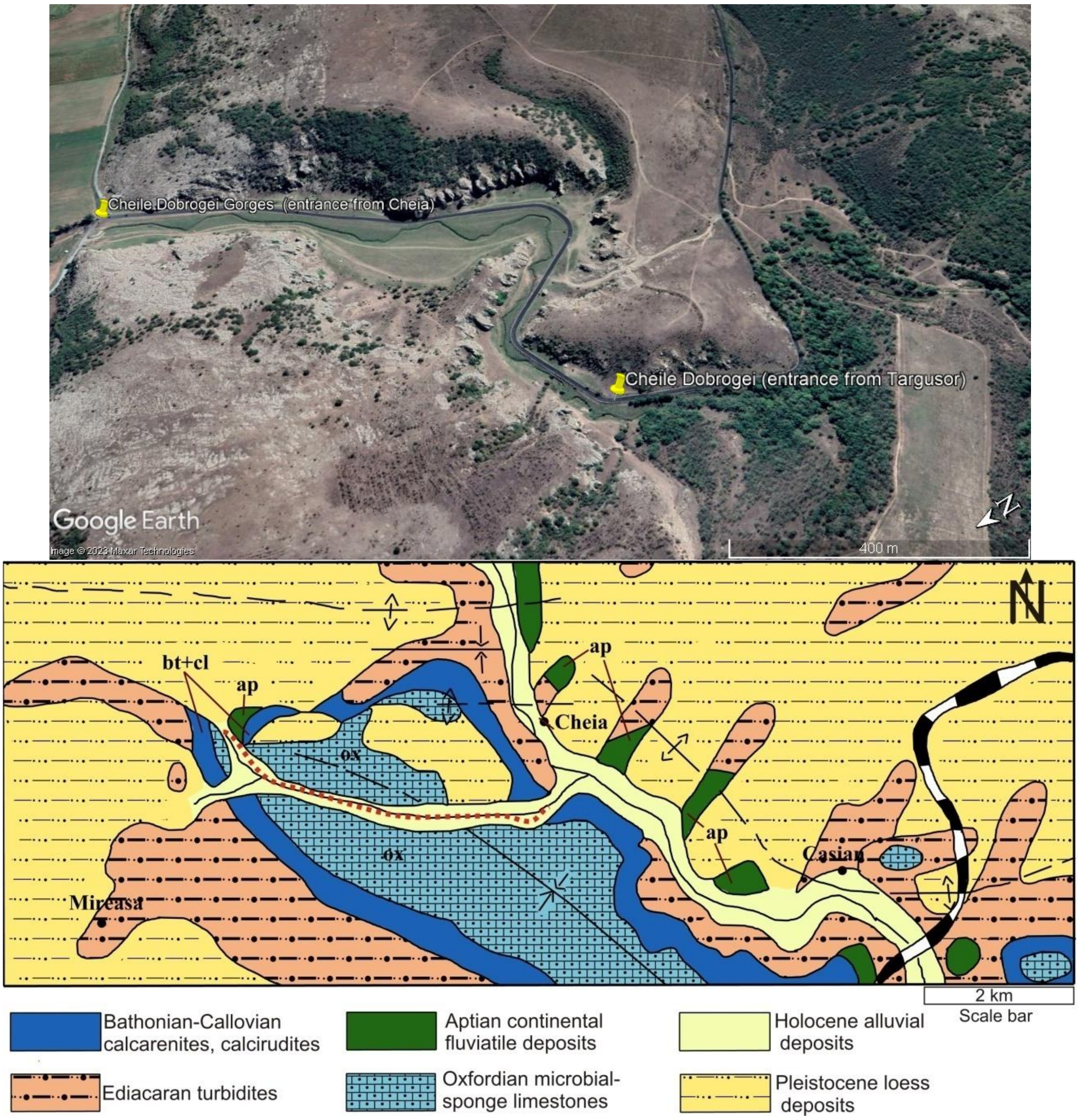

Fig. 13.1. Location of the Dobrogei Gorges on Google Earth and on the geological outline map (red dotted line) of Central Dobrogea (based on Chiriac et al., 1968).

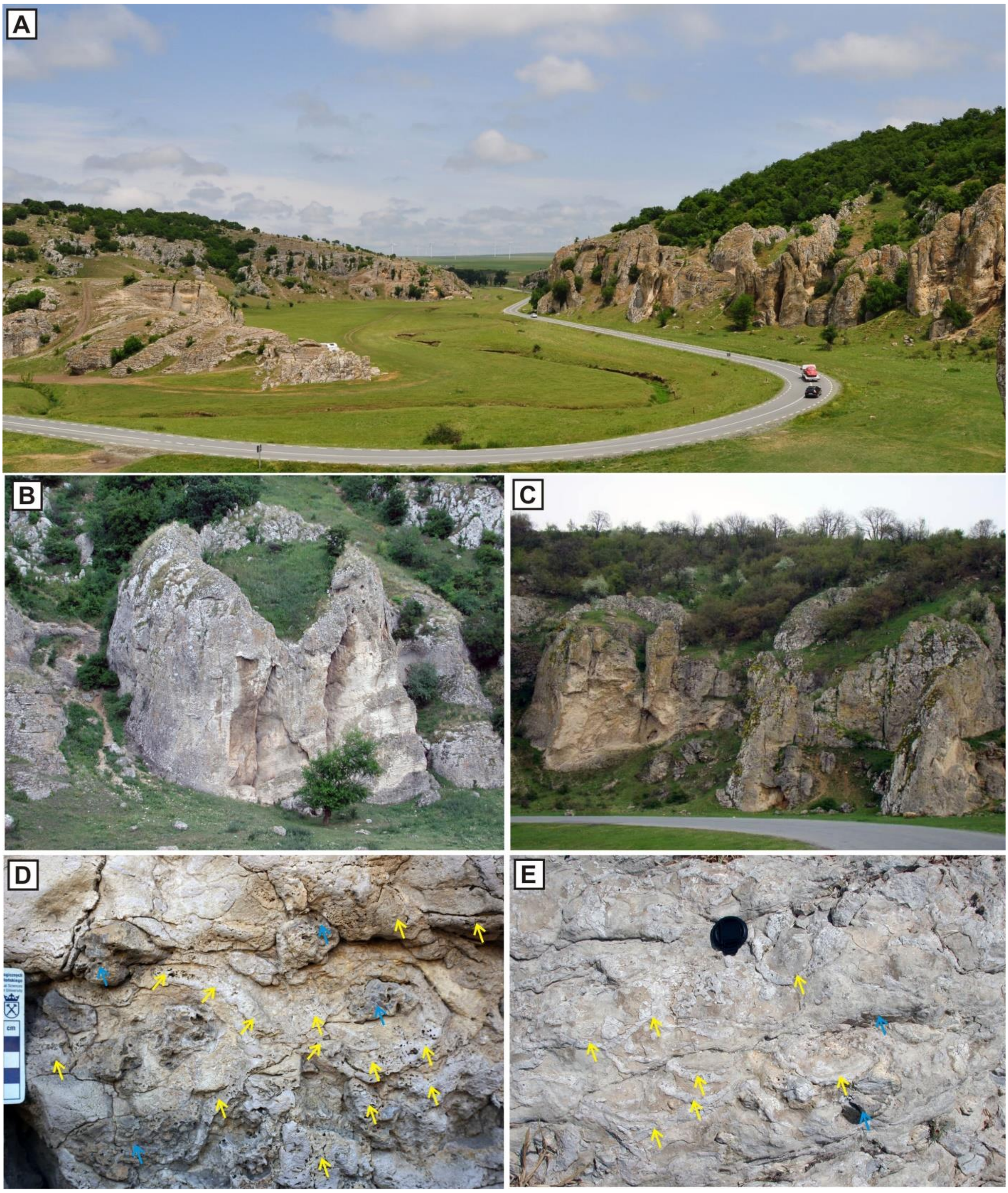

Fig. 13.2. A - Dobrogei Gorges along Visterna Valley; **B,C** - microbial-sponge limestones forming spectacular ring-shaped bioherms and biostromes; **D, E** – Detail view of the microbial-sponge limestones forming the wall of the bioherms: calcified siliceous sponges (yellow arrows) and chert nodules (blue arrows).

Description (synthesis from Bărbulescu, 1971, 1972; Bărbulescu in Dragastan et al., 1998; Hermann, 1996; and personal observations): the Visterna Member consists of 20-90 meters thick microbial-sponge carbonates, () widely developed on the territory of Central Dobrogea. The basal part of Visterna Member (lower-middle Oxfordian) is represented by microbial crusts and platy sponges forming successive biostromes intercalated with bioclastic packstone-wackestone. The following part of Visterna Member is also represented by microbial-sponge limestones forming spectacular ring-shaped bioherms (20-70 meters high and 15-30 meters diameter), a feature of the microbial-sponge peri-Tethyan megafacies observed only in Romania. The wall thickness of the bioherms reaches 2 to 5 meters, and is composed mainly of siliceous sponges and microbial crusts. The bioherms reveal an early cemented microbial framework (thrombolites and dense peloidal stromatolites) that was settled by hexactinellid sponges and lithistid demosponges. The lithistid demosponges dominate the assemblage (80%) and are represented mainly by the genus *Plathyconia*, with subordinate *Hyalotragos* and rare *Cylindrophyma*. The hexactinellid sponges are represented by genera such as: *Stauroderma*, *Trochobolus*, *Craticularia*, *Sporadophyle*, *Tremadictyon*. The microbial crusts and sponges are encrusted by serpulid tube-worms (*Cycloserpula*, *Dorsoserpula*, *Tetraserpula*), bryozoans (*Stomatopora*, *Plagioecia*, *Ceriocava*), benthic foraminifera, encrusting sponges (*Neuropora spinulosa*), and cemented brachiopods (*Rioultina*, *Crania*, *Craniscus*), and are bioeroded by endolithic bivalves. The interior of the bioherms is filled with thrombolitic microbialites, fine-grained stromatolites, and bioclastic packstone-wackestone. The biostrome limestones between the bioherms dip towards the bioherm walls in their basal part and touch the wall at right angle toward their upper part. The biostromal microbial-sponge limestones contain rare bivalves (ostreoids and pectenids), rare gastropods, brachiopods (*Lacunosella cracoviensis*, *Moeschia alata*, *Argovithyris birmensdorfensis*), rare echinoids (*Cidaris*, *Collyrites*) and ammonites (*Peltoceratoides*, *Neoprionoceras lautlingense*, *Lissoceratoides erato*, *Sowerbyceras tortisulcatum*, *Gregoryceras riazi*, and specimens referred to Perisphinctidae). Feldmann et al. (2006) described primitive brachyurans of the family Prosopidae from the microbial-sponge limestones of the bioherms.,

The early – middle Oxfordian age of the basal and middle part of Visterna Member was documented by Bărbulescu (1971, 1972, 1979) using ammonite faunas. For the upper part of Visterna Member, the brachiopods and echinoderm assemblages indicate a late Oxfordian age (Bărbulescu in Dragastan et al., 1998).

The biostratigraphy and detailed paleoecological interpretation of the Visterna Member were outlined by Bărbulescu in Dragastan *et al*. (1998), while their microfacies and paleoenvironmental assessment was accomplished by Hermann (1996). The cylindrical bioherms are considered to have been formed over subtle elevations on the seafloor of the distal middle ramp, below fair weather wave base. Although there is little physical evidence to document the elevation of the rings above the seafloor during their growth, Hermann (1996) speculated that they were probably low-relief features. As each cylindrical bioherm reaches a diameter of approximately 30 m, this suggests that some biotic or hydraulic-dynamic factor may have governed the size of these buildups. It is possible that this was the optimal size to provide adequate water circulation in order to sustain the bioherm-building organisms.

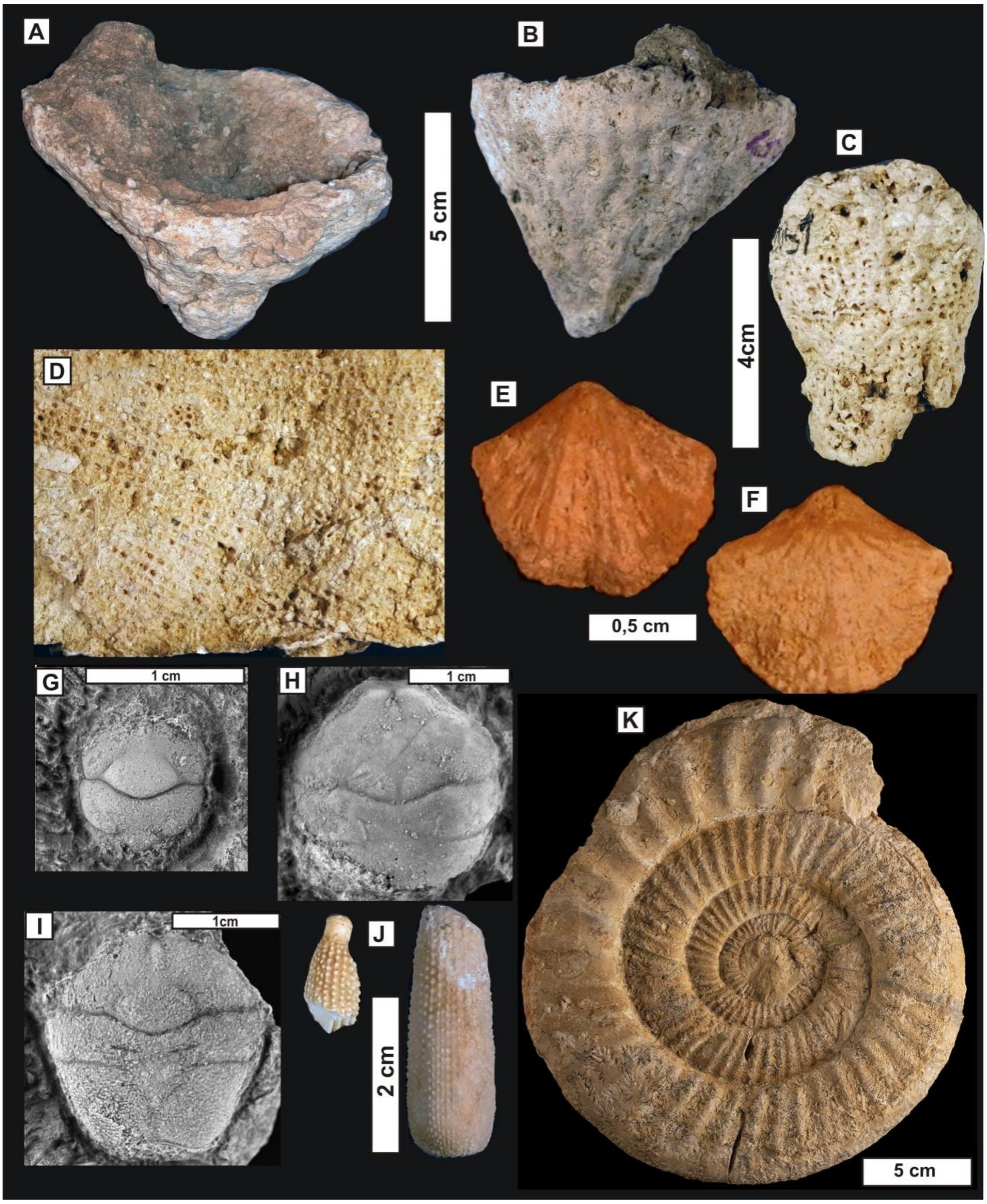

Fig. 13.3. Macrofossils from the microbial-sponge magafacies, Dobrogei Gorges: **A, B** - *Cribrospongia reticulata* (GOLDFUSS); **C** - *Tremadictyon* sp.; **D** - *Laocoetis paradoxa* (Münster); **E, F** - Spriferinida brachiopod; **G** - *Pithonoton* sp.; **H** - *Cycloprosopon dobrogea* Feldmann et al., 2006; **I** - *Goniodromites* sp.; **J** - cidaroid radiola (spines); **K** - *Arisphinctes cotovui* Simionescu, 1907.

Stop 14. Ediacaran anchimetamorphic turbidites of Histria Formation, with ripple marks intersected by slaty cleavages

Stratigraphy: Histria Formation (Ediacaran).

Location: Cogealac Valley, 3 km N from Tariverde Village (44°34'27.10"N, 28°35'21.50"E)

Description: Outcrops on the right slope of Cogealac Valley expose large bedding surfaces of the distal turbidites of the Histria Formation,with extremely well preserved ripple marks. They occur mainly as longitudinal ripples, sometimes with double crests (Fig. 14.1.) (Oaie, 1999). Occasionally, drag marks also occur on the bedding planes (Fig. 14.2).

Although the turbiditic succession is affected by a steeply dipping, penetrative slaty cleavage, this does not obliterate the sedimentary structures. The intersection of the cleavage planes with the bedding surfaces modelled by ripples results in an intersection lineation (Fig. 14.3.) observable across the entire outcrop area. Moreover, the succession of sedimentary facies is often visible on the cleavage surfaces.

Fig. 14.1. Longitudinal ripples with straight or undulating crests, visible on large bedding surfaces at Tariverde.

Fig. 14.2. Drag mark superimposed on the large, rippled surface at Tariverde.
Note the S_o/S_1 intersection lineation visible as thin lines on the surface of the ripples.

Other sedimentary structures visible on the bedding planes are wrinkles (Saint Martin et al., 2011, 2013) (Fig. 14.3). Known in Ediacaran deposits from India and Australia, wrinkle structures are interpreted as evidence for preservation favored by the existence of microbial mats.

Fig. 14.3. Wrinkle structures on turbidite bedding planes near Tariverde.

Measurements of ripple marks and various current marks (Jipa, 1968, 1970; Oaie, 1999) represent the basis of the paleocurrent map of the Histria Formation. Detailed paleoflow measurements indicate a major source located to the SE, with minor input from the north, probably from intrabasinal highs (Oaie, 1999). The solid discharge was redistributed by longitudinal currents flowing from E to W. The depositional basin of the turbidites is interpreted as a peripheral foreland basin, with only its internal part preserved in the exposed Histria Formation (Oaie, 1999; Oaie *et al*., 2005).

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