Rivista Italiana di Paleontologia e Stratigrafia
(*Research in Paleontology and Stratigraphy*)
vol. 125(1): 91-123. **March 2019**

UPPER SPATHIAN TO BITHYNIAN (LOWER TO MIDDLE TRIASSIC) BRACHIOPODS FROM NORTH DOBROGEA (ROMANIA)

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To cite this article: Grădinaru E. & Gaetani M. (2019) - Upper Spathian to Bithynian (Lower to Middle Triassic) brachiopods from North Dobrogea (Romania). *Riv. It. Paleontol. Strat.*, 125(1): 91-123.

Keywords: Brachiopods; systematics; upper Spathian; Aegean; Bithynian; North Dobrogea.

Abstract. Brachiopods obtained from several Triassic localities in North Dobrogea, in Romania, are described. Upper Spathian and Aegean Hallstatt-type red limestones have been sampled in the Deşli Caira section, proposed as the GSSP for the base of the Anisian. The Bithynian brachiopods mostly originate from the *Tubiphytes*-microbial buildup in the Mahmudia quarry, and also from the Hallstatt-type limestones of Agighiol and Orta Bair. Their age estimates are supported by ammonoids collected from the same beds.

The upper Spathian and Aegean assemblages of Deşli Caira consist of four rhynchonellids, with one genus and two species newly described, *Ortarhynchia petersi* gen. n. sp. n. and *Austriellula iordanae* sp. n. The Bithynian assemblages comprise the most diverse fauna, with 15 species, four species of which are newly described, *Ortarhynchia petersi* gen. n. sp. n., *Piarorhynchella kittli* sp. n., *Ptychomentzelia dobrogeana* sp. n. and *P. simionescui* sp. n. In the *Tubiphytes* facies of Mahmudia, the assemblage is numerically dominated by mentzeliids and dielasmatids, forming 84.8 % of the whole assemblage. Spiriferinids and rhynchonellids form the minor component. Instead, rhynchonellids prevail in the Hallstatt facies at Agighiol and Orta Bair.

The assemblages described here are hardly comparable with those of the western Tethys. The Bithynian assemblage is very different from its equivalent described from the substage stratotype in Turkey. In North Dobrogea, the carbonate substrate and clear and agitated water supported an assemblage with high diversity. In contrast, in Bithynia, the brachiopod community dwelled on a softer and muddier substrate, with higher density and lower diversity. The locality of Aghdarband (Iran) also delivered Bithynian brachiopods, forming another different assemblage. The recovery and radiation of brachiopods after the P/T crisis is discussed in the framework of Palaeo-Tethyan palaeogeography, making comparisons with the South China localities.

Introduction (E. Grădinaru)

Bounded on the north by the Danube Delta and rimmed on the east by the Black Sea, the North Dobrogea region is a fold-and-thrust belt, commonly named as the North Dobrogean Orogen (Săndulescu 1995; Visarion et al. 1990). It is located on the western tip of the Cimmerian Orogenic System, which continues eastwards with the Mountainous Crimea, North Caucasus and extends furthermore to the Asian Cimmerides (Şengör 1984, 1986). The North Dobrogean Orogen is tectonically bounded to the north by the Galaţi-Sfântul Gheorghe Fault and to the south by the Peceneaga-Camena Fault, which separate it from the Scythian Platform on the north and from the Moesian Platform on the south, respectively (Fig. 1). The North Dobrogean Orogen includes several tectonic units, namely the Măcin, Consul, Niculiţel and Tulcea units, which are overthrust north-easterly (i.e. Săndulescu 1984; Visarion et al. 1990).

The Triassic sedimentary series that unconformably overlies a Variscan basement has the widest extension in the Tulcea Unit of the North Dobrogean Orogen, with basinal facies developed westwards in its inner part and a carbonate platform facies that extends in the mid-eastern part

Received: September 02, 2018; accepted: January 4, 2019

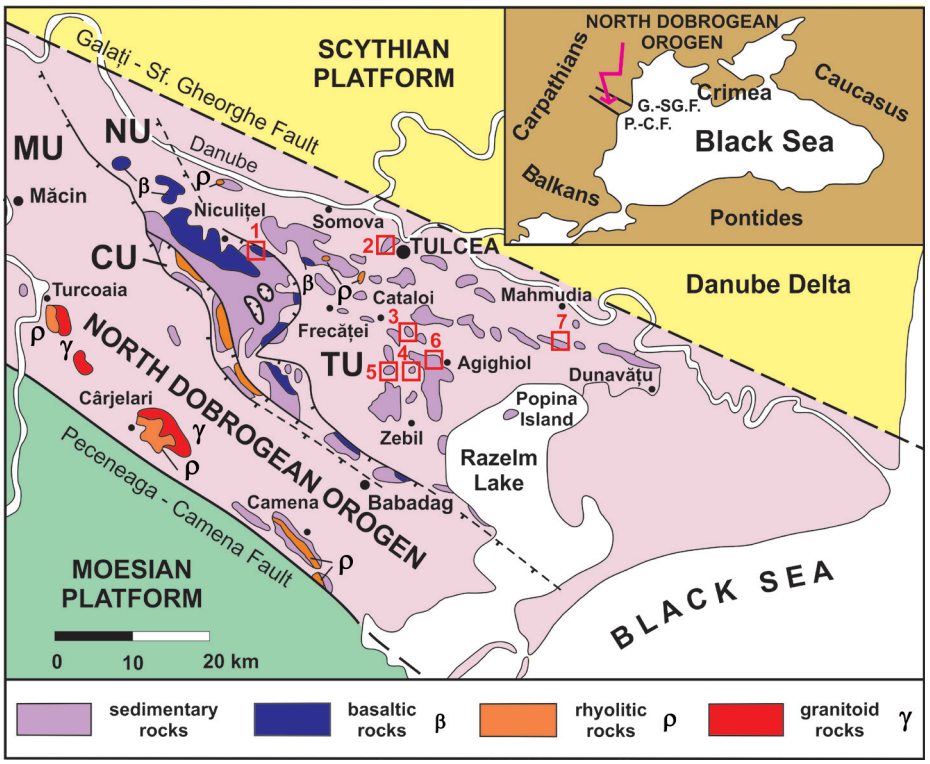

Fig. 1 - Tectonic sketch map of the North Dobrogean Orogen with locations (red rectangles) of the studied brachiopods and those published in previous references. Insert map shows the regional geological setting of the North Dobrogean Orogen. *Abbreviations*: MU - Măcin Unit, CU - Consul Unit, NU - Niculiţel Unit, TU - Tulcea Unit (modified after Grădinaru, 2000). 1 - Sarica, for the lower Spathian; 2 - Tulcea Veche, for the lower Spathian; 3 - Deşli Caira hill, for the upper Spathian-Aegean; 4 - Orta Bair hill, for the Bithynian; 5 - Mandra, for the upper Spathian-Aegean; 6 - Agighiol hills, for the Bithynian); 7 - The Mahmudia quarry, for the Bithynian.

(Grădinaru 1995, 2000). The carbonate platform was tectonically dissected by synsedimentary faulting into a complex network of pelagic swells and deep depressions. As a result, in the middle part of the Tulcea Unit, Middle and Upper Triassic deep-water sequences of reddish and greyish cherty, nodular limestones and varicoloured marly shales diachronously interfinger with thick sequences of Hallstatt-type thick-bedded limestones.

The present-day remote location of the North Dobrogean Triassic occurrences, placed outside of the Mediterranean Triassic, is currently interpreted as the result of the post-Triassic large-scale horizontal displacements of Tethyan terranes and the opening of the West Black Sea Basin (e.g. Grădinaru 1988; Okay et al. 1994; Banks & Robinson 1997).

The Triassic development of North Dobrogea is well known in the relevant literature for its Tethyan-type facies and richness in various groups of fossils (Arthaber 1906; Kittl 1908; Simionescu 1927; Tozer 1984; Grădinaru 1995, 2000). Ammonoid faunas, alongside brachiopods, bivalves and gastropods, have been described in classic monographs by Kittl (1908) and Simionescu (1910a-b, 1911, 1913a, 1925), with Agighiol (former Hagighiol) as the reference locality. More recent studies on the cephalopods, brachiopods, gastropods, bivalves, conodonts, ostracods and foraminifers have been done by Mirăuţă & Gheorghian (1975), Mirăuţă & Iordan (1982), Mirăuţă et al. (1984, 1993), Crasquin-Soleau & Grădinaru (1996), Grădinaru & Sobolev (2006), Grădinaru et al. (2006, 2007), Orchard et al. (2007), Sebe et al. (2013), Forel and Grădinaru (2018), and Nützel et al. (2018). The potential for delivering vertebrate fossils (ichthyosaurs and coelacanths) is revealed by Simionescu (1913b) and Cavin & Grădinaru (2014), and Martin and Grădinaru (work in progress).

Lastly, it is worth mentioning that the first-ranked GSSP candidate for the base of the Anisian is represented by the Deşli Caira section, which is located in the Triassic classic area of Agighiol, in the Tulcea Unit (Grădinaru 2000; Grădinaru et al. 2006, 2007; Orchard et al. 2007; Ogg et al. 2016).

With special reference to the Triassic brachiopods from North Dobrogea, data have been published by Peters (1867), Kittl (1908), Simionescu (1910a-b, 1911, 1913), Mirăuţă et al. (1984) and Iordan (1993).

For the Spathian to the Bithynian stratigraphic interval, on which the present paper is focused, brachiopods of this age have been mentioned only by Kittl (1908), Simionescu (1910a), Mirăuţă et al. (1984) and Iordan (1993).

Simionescu (1911) mentioned the presence of *Spiriferina* sp. and *Rhynchonella* sp. in the lower Spathian *Tirolites* beds from the Tulcea Veche quar-

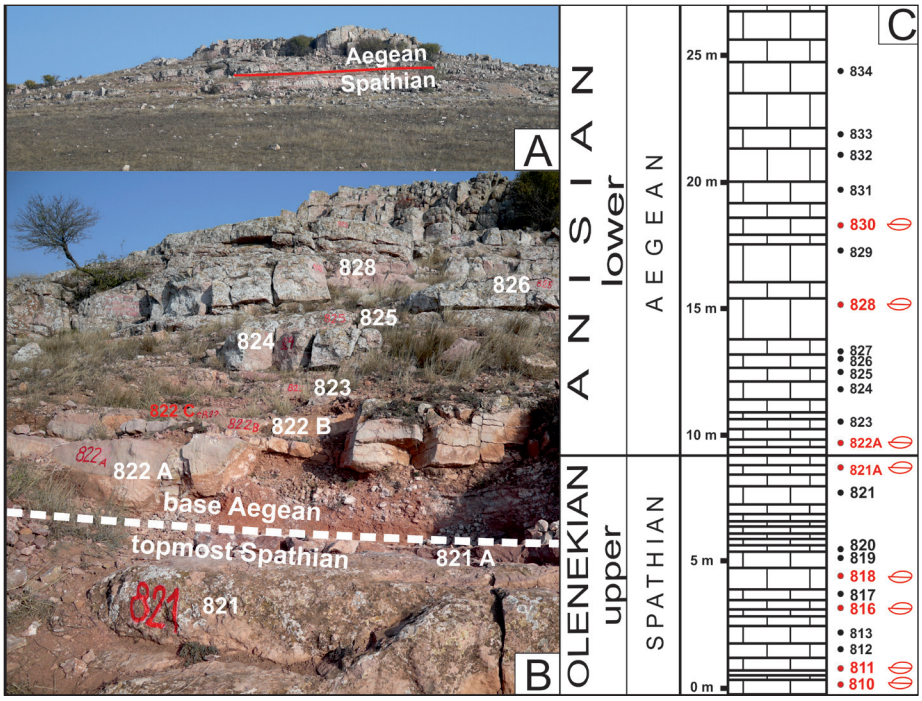

Fig. 2 - A) General view of the Deşli Caira hill from the south. B) The Spathian/Aegean boundary at the Deşli Caira hill, between samples 821A and 822A. C - Stratigraphic log for the Deşli Caira section, with the layers (in red color) that delivered the studied brachiopods.

ry, but due to their fragmentary state these brachiopods could not be assigned to definite species.

Kittl (1908) cited *Spirigera marmorea* var. *auriculata* Bittner from Deşli Caira (Taşli, in Kittl), while, from Mandra, located westward of Agighiol, the same author cited *Rhynchonella* cf. *arcula* Bittner, *Rhynchonella refractifrons* cf. var. *bosniaca* Bittner, *Spirigera marmorea* var. *auriculata* Bittner, *Spirigera* aff. *S. balatonica* Bittner, and *Retzia* sp. Also from Deşli Caira, Simionescu (1910a) described and illustrated a brachiopod fauna that includes *Rhynchonella* (*Norella*) *kellneri* Bittner, *Spirigera marmorea* var. *auriculata* Bittner, *Rhynchonella* aff. *R. nux* Suess, *Rhynchonella* sp. The brachiopods reported from Deşli Caira by Kittl (1908) and Simionescu (1910a) originate from Hallstatt-type limestones that, based on the present ammonoid and conodont biostratigraphic data, are latest Spathian to Aegean in age (Grădinaru et al. 2006, 2007; Orchard et al. 2007).

Mirăuţă et al. (1984) cited from the Sarica region and illustrated *Spirigerellina* cfr. *pygmea* Dagys and *Fletcherithyris margaritovi* (Bittner), which in view of the associated conodonts, bivalves and the ammonite *Tirolites* cf. *spinosus* Mojsisovics, are dated as early Spathian.

Iordan (1993) illustrated a few brachiopods from the lower Spathian. Also, she quoted several species from the Anisian (Pelsonian and Illyrian) from different localities in the central and eastern part of the Tulcea Unit, but their ages are not properly constrained biostratigraphically. The taxonomic assignments have to be revised for most of the material.

Unfortunately, the repository of the materials cited by Kittl (1908), Mirăuţă et al. (1984) and Iordan (1993) has not been identified yet. Only a few specimens illustrated by Simionescu (1910a) are preserved in the Museum of Palaeontological Collections in the University "Alexandru Ioan Cuza" of Iaşi (fide Turculeţ & Brânzilă 2012, p. 90).

Stratigraphy (E. Grădinaru)

The late Spathian to Bithynian brachiopods studied in the present paper originate from the successions exposed in the hill of Deşli Caira (upper Spathian to Aegean) and in the regions of the Agighiol (Bithynian), Orta Bair (Bithynian), and Mahmudia (Bithynian) localities. The materials were collected by the first author (EG) over several decades.

Deşli Caira (Fig. 2A). The front of the quarry (45°04'24.71" N, 28°48'04.92 " E) exposes a total of 5 m of mixed reddish to light grey coloured limestones that grade upwards into brick-red coloured limestones at the top of the quarry face. Subordinate "*Posidonia*"-bearing, pale coquinoid limestones are interbedded with the Hallstatt-type limestones. The Olenekian-Anisian Boundary (OAB) is located

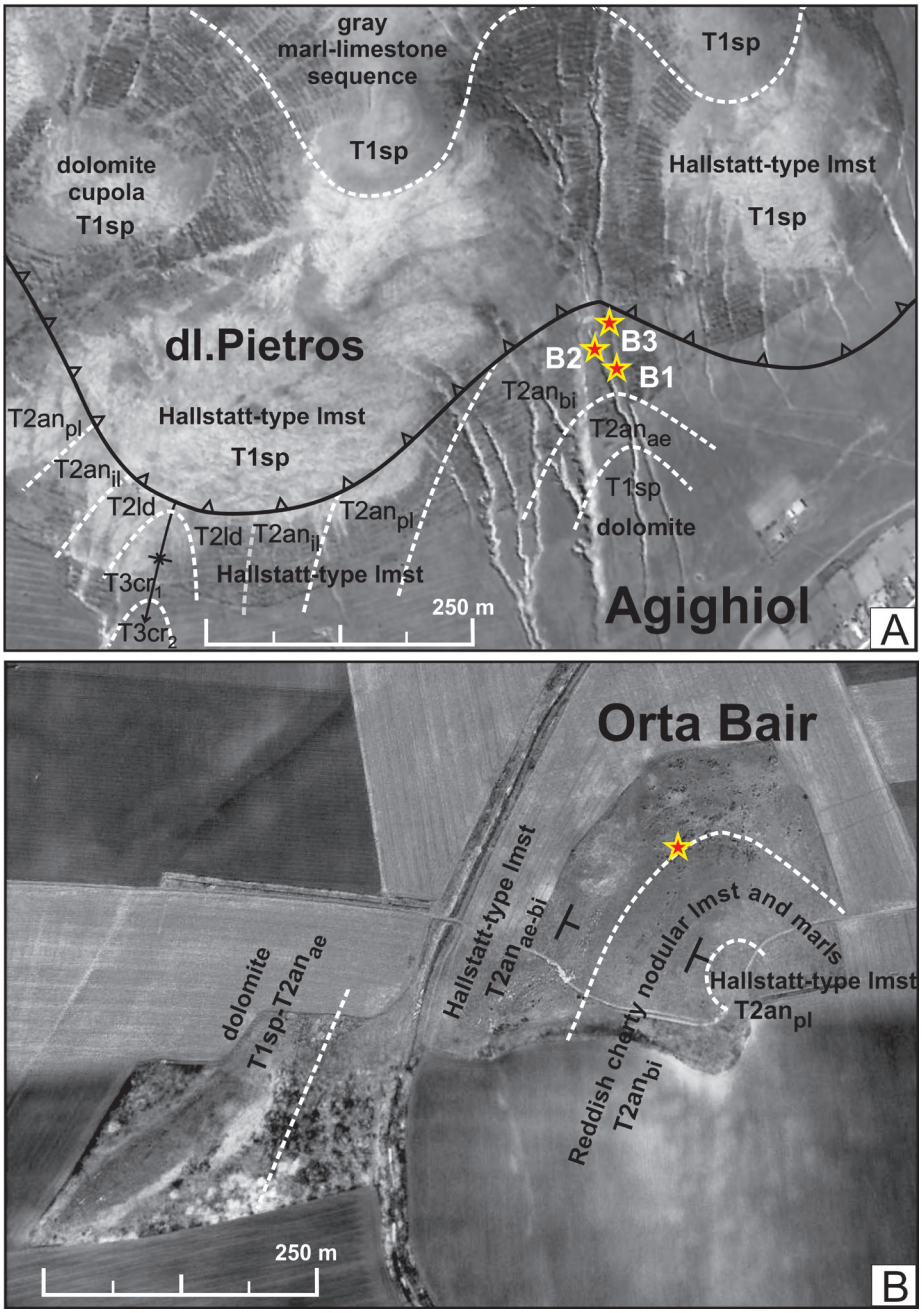

Fig. 3 - Google Earth images (data © 2012 Digital Globe) showing the locations, by stars, of the studied Bithynian brachiopods at the hills of the Agighiol village, with B1, B2 and B3, and at the hill of Orta Bair.
Explanation: white dashed line for stratigraphic boundary; dark barbed line for overthrust, with barbs on the upthrown side.
Abbreviations: Lower Triassic, Spathian - T1sp; Middle Triassic, Anisian (Aegean, Bithynian, Pelsonian, Illyrian) and Ladinian - T2anae, T2anbi, T2anpl, $T2an_{il}$, T2la; Upper Triassic: $T3cr_1$ - lower Carnian; $T3cr_2$ - upper Carnian.

just above the top of the quarry (Fig. 2B). Above the OAB, the basal part of the lower Anisian is made up almost exclusively of thick-bedded, brick-red coloured Hallstatt-type limestones, with only rare intercalations of "*Posidonia*" bearing reddish coquinoid limestones. The Hallstatt-type limestones are extensively bioturbated at some levels, with mottled aspects, and, in a few layers, they show condensed sedimentation features; small open-space features are present in the upper part of the section. The sequence yielded abundant ammonoids and fewer nautiloids of late Spathian to Aegean age. Other macrofaunas are poorly represented, with rare occurrences of small-sized brachiopods, gastropods and crinoids, and thin shelled bivalves at a few levels.

From the upper Spathian part, layers 810, 811, 816, and loose blocks from 816 to 821 (Fig. 2C) delivered three species (19 specimens): *Norella kellneri* Bittner, 1892, *Austriellula iordanae* sp. n., and *Ortarhynchia petersi* gen. n. sp. n.

From the Aegean part, layers 822A, 828 and 830 (Fig. 2C) contain three species (11 specimens): *Austriellula iordanae* sp. n., *Ortarhynchia petersi* gen. n. sp. n. and *Costirhynchopsis* sp. A.

The high-resolution ammonoid biostratigraphy in the Deşli Caira section, which was achieved in the last decade due to bed-by-bed investigation

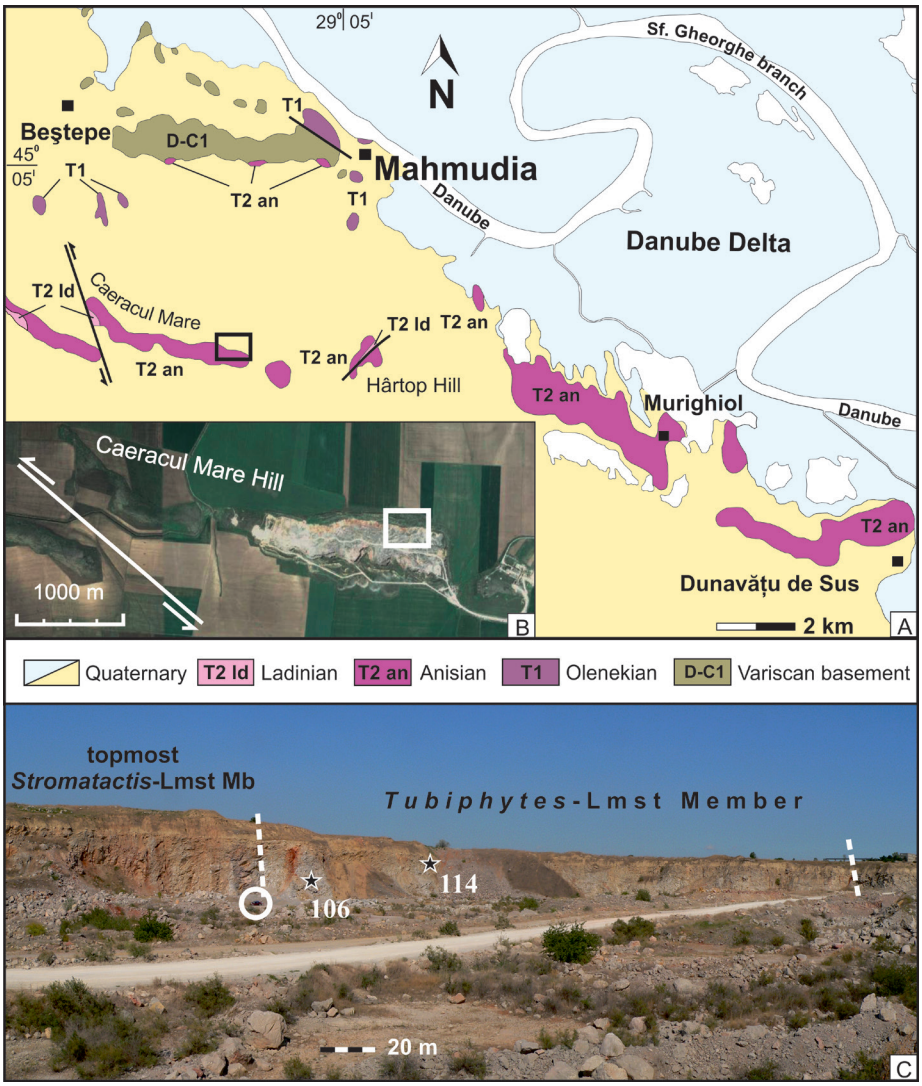

Fig. 4 - Geological map of the Mahmudia region (A) showing the location of the Mahmudia quarry (black rectangle). B) Google Earth image (data © 2015 CNES/ Astrium) of the Mahmudia quarry (white rectangle). C) Photo of the northeastern corner in the Mahmudia quarry showing the section of the *Tubiphytes*-Limestone Member, and the stratigraphic levels of the studied Bithynian brachiopods (layers 106 and 114). Circled car on the left side for scale.

(Grădinaru, work in progress), accurately demonstrates that the Spathian/Aegean boundary is placed a little higher in the section than had been previously estimated by Grădinaru et al. (2007). It is now placed between the levels 821 and 822A. The topmost part of the level 821 (821A) yields the uppermost Spathian ammonoid assemblage, including *Procarnites kokeni* (Arthaber, 1908), *Eogymnites arthaberi* (Diener, 1915), *Proptychitoides* sp., *Albanites* sp., and others, whilst the level 822A yields a lowermost Aegean ammonoid assemblage, including *Aegeiceras ugra* (Diener, 1895), *Paracrochordiceras* sp., *Japonites* sp., *Stenopopanoceras* sp., *Lenotropites* sp., and others. *Aegeiceras ugra* extends till layer 830.

Agighiol (Fig. 3A). Westward and near the Agighiol village, the Bithynian brachiopods come from thick-bedded, variously coloured, cream to cream-pinkish and grey limestones exposed in deep ravines north of the hill Dealul Pietros. They were collected in three separate outcrops, B1 (45°01'53.24" N, 28°51'47.57" E), B2 (45°01'51.82" N, 28°51'47.71" E), and B3 (45°01'53.20" N, 28°51'43.95" E), presently included in the Agighiol Natural Protection area. From Agighiol (18 specimens) originate *Norella kellneri* Bittner, 1892 and *Ortarhynchia petersi* gen. n. sp. n.

The Bithynian age of the brachiopods is properly documented by a rich assemblage of ammonoids, with species of *Acrochordiceras*, *Platycuccoceras*, *Intornites*, *Nevadisculites*, *Phyllocladiscites*, *Ussurites, Gymnites* and other genera.

Orta Bair (Fig. 3B). At the hill of Orta Bair (45°01'40.76" N, 28°48'31.84" E), located 4 km west of the Agighiol village, the Bithynian brachiopods come from medium- to thick-bedded Hallstatt-type reddish limestones that are exposed on the western side of the hill. Three species are present. *Norella kellneri* Bittner, 1892, *Austriellula iordanae* sp. n. and *Ortarhynchia petersi* gen. n. sp. n.,

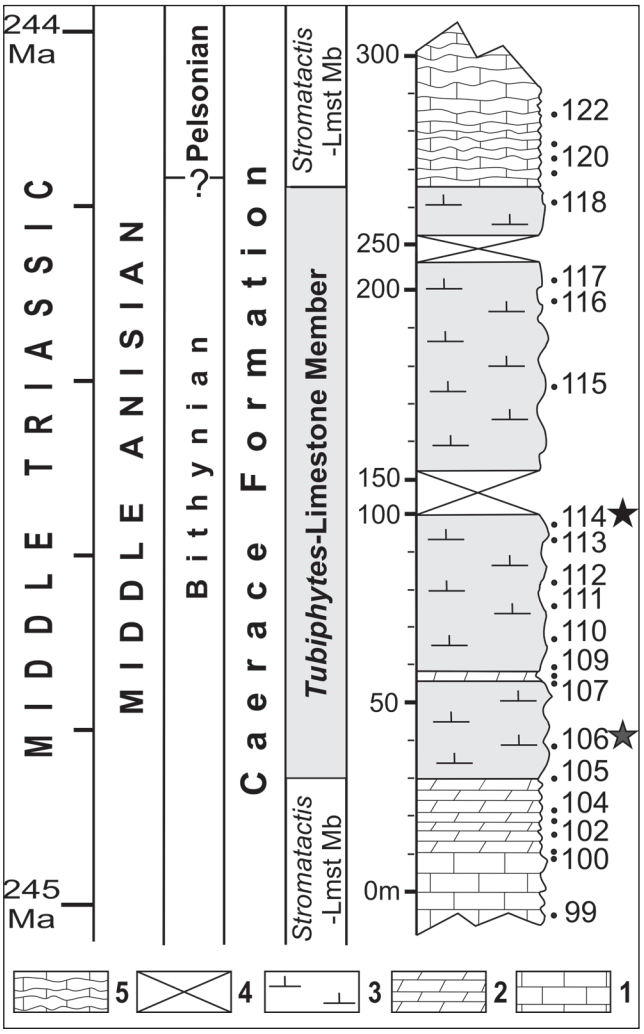

Fig. 5 - Stratigraphic log for the *Tubiphytes*-Limestone Member in the Mahmudia quarry showing the position of the layers 106 and 114 (main layer) of the studied Bithynian brachiopods. *Lithologies*: 1, thick-bedded limestone; 2, bedded grey limestone; 3, massive *Tubiphytes*-limestone; 4, section covered with quarried material; 5, bedded streaky grey limestone.

originate from a single layer at the top of Hallstatt-type limestones at this locality (14 specimens). The associated ammonoid fauna includes species of *Acrochordiceras, Hollandites*, *Robinsonites, Pseudodanubites, Ussurites, Gymnites* and other Bithynian genera.

Mahmudia (Fig. 4). The studied brachiopods come from middle Anisian carbonate rocks that are exposed in a 1.5 km-long limestone quarry located in the Caeracul Mare hill area (45°03'12.41" N, 29°03'34.52" E), south of the village of Mahmudia. The Caerace Formation, which includes middle Anisian carbonate rocks, is divided into two distinct lithostratigraphic subunits, the *Stromatactis*-Limestone Member and the *Tubiphytes*-Limestone Member. From the *Stromatactis*-Limestone Member only a single valve of *Koeveskallina* sp. was collected. The microfacies and depositional environment have been described in detail by Popa et al. (2014). The brachiopods were collected almost exclusively from the *Tubiphytes*-Limestone Member, at two stratigraphic levels, layers 106 and 114. The second level is by far the richest, the studied brachiopods being extracted from only 1.5 cubic meters of rock (Fig. 5). The stratigraphic section of the *Tubiphytes*-boundstones, about 250 m thick, which contained brachiopods is exposed in a vertical wall in the northeastern part of the Mahmudia quarry. As shown by Popa et al. (2014), the *Tubiphytes*-boundstones are a massive carbonate buildup, lacking any visible bedding and showing a mixture of different carbonate facies, with frequent, microbially-mediated cement crusts (Fig. 6). These are very fossiliferous in various groups of macroinvertebrates, including ammonoids, nautiloids, gastropods, brachiopods, bivalves, sponges and crinoids, the gastropods and the bivalves being described by Nützel et al (2018) and Friesenbichler et al. (submitted). A very rich ostracod assemblage has been reported by Forel & Grădinaru (2018). When broken, the rock releases a pungent smell of rotten eggs. The high mass mortality ensured a high organic matter content to the carbonate sediment, and thus the reachness in nutrients of the *Tubiphytes* facies. The Bithynian *Tubiphytes*-microbial facies from North Dobrogea may be viewed as a chemosynthetically-driven oasis for various groups of organisms (Grădinaru 2017). The breakdown of organic matter by specific chemosynthetic microbial consortia enabled the richness of nutrients for the superabundant biota in the *Tubiphytes*-microbial facies of North Dobrogea (Forel & Grădinaru 2018; Nützel et al. 2018; Friesenbichler et al. submitted).

The Middle Anisian *Tubiphytes*-microbial reef was firstly documented in North Dobrogea by Popa et al. (2014), and this is the only known reef of this kind in the western part of the Cimmeride Orogenic System. It is evidence, with other examples worldwide (e.g. Stanley 1988; Senowbari-Daryan et al. 1993; Flügel 2002; Payne et al. 2006), of the recovery of carbonate production after the major biotic crisis at the Permian-Triassic boundary.

The early middle Anisian age (referred as the Bithynian substage in the standardized *Geologic Time Scale 2016* published under the auspices

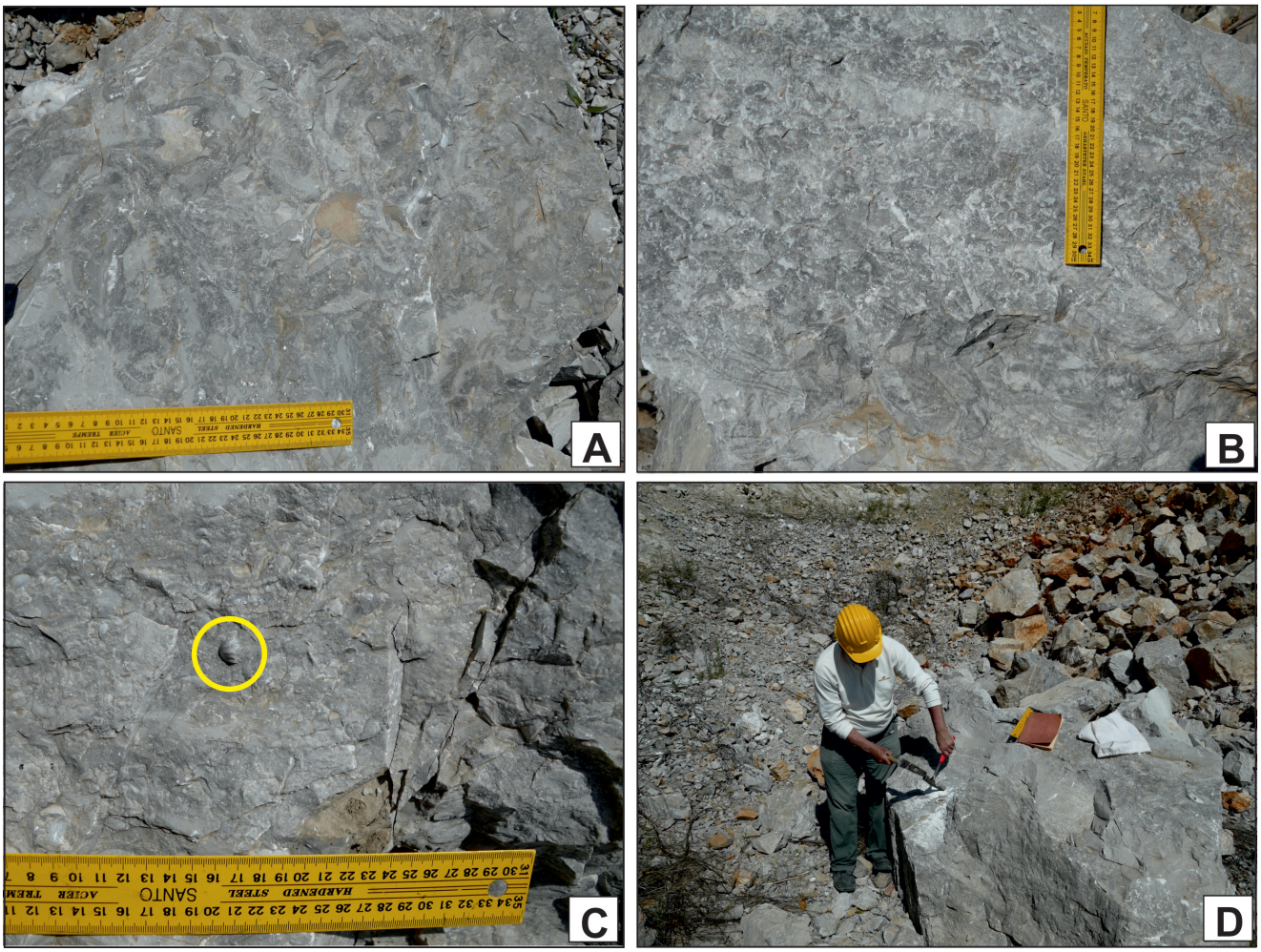

Fig. 6 - Photos showing packages of rich-fossiliferous boundstone bearing microbially-mediated cement crusts (A, B and C) in the *Tubiphytes*-Limestone Member at stratigraphic level 106. Circled in C it is a rhynchonellid brachiopod. D) The first author extracting the brachiopod from C.

of the International Commission on Stratigraphy, e.g. Ogg et al. 2016; see also Shevyrev 1990; Mietto & Manfrin 1995) of the brachiopods is fully documented by a rich and diverse ammonoid assemblage (Grădinaru, work in progress). The ammonoid assemblage of the *Tubiphytes*-buildup limestones includes *Robinsonites* sp., *Alanites* aff. *A. visendus* Shevyrev, 1968, *Gymnites* aff. *G. tozeri* Bucher, 1992, *Megaphyllites prometheus* Shevyrev, 1961, *Longobarditoides solimani* (Toula, 1896), *Hollandites silberlingi* Bucher, 1992, *Caucasites inflatus* Shevyrev, 1968, *Acrochordiceras hyatti* Meek, 1877, *Ussurites* aff. *U. arthaberi* (Welter, 1915), and others.

The ammonoid assemblage is similar to those of the lower middle Anisian (Bithynian) of the North-Western Caucasus (Shevyrev 1995) and the lower part of the Hyatti Zone in the middle Anisian of Western Nevada (Silberling & Nichols 1982; Bucher 1992; Monnet & Bucher 2006).

The brachiopod assemblage consists of 12 species (113 complete specimens and 34 incomplete specimens): *Piarorhynchella kittli* sp. n., *Costirhynchopsis* sp. B, *Costirhynchopsis* sp. C, *Punctospirella* sp. ind., *Dinarispira* sp. ind., *Koeveskallina* sp. A, *Koeveskallina* sp. B, *Ptychomentzelia dobrogeana* sp. n., *P. simionescui* sp. n., *Adygella* sp. ind., *Sulcatinella* aff. *S. incrassata* (Bittner, 1890), and *Rhaetina* sp. ind.

Methods. The brachiopods have been mechanically cleaned and prepared. The internal structures were studied by serial sections, taking photographs and making peels at each step of grinding.

Repository of the material. The material is housed in the Museum of the Laboratory of Palaeontology in the University of Bucharest, with Catalogue numbers LPB IIIb 800 to LPB IIIb 880. The numbers refer to the catalogue for Brachiopoda from Romania.

Systematic palaeontology (M. Gaetani)

The brachiopod fauna under study consists of 16 species. Nine of them are represented by a single or very few specimens, and not fit for full description and therefore left in open nomenclature. However, it was decided to illustrate all of the material collected in order to give a comprehensive view of the new fauna. The classifications of Manceñido & Owen (2001), Savage et al. in Williams et al. (2002), Carter in Williams et al. (2006), and Jin et al. in Williams et al. (2006) are followed in the systematic description.

Phylum BRACHIOPODA Duméril, 1806
Subphylum RHYNCHONELLIFORMEA Williams, Carlson, Brunton, Holmer & Popov, 1996
Class **Rhynchonellata** Williams, Carlson, Brunton, Holmer & Popov, 1996
Order **Rhynchonellida** Kuhn, 1949
Superfamily Norelloidea Ager, 1959
Family Norellidae Ager, 1959
Subfamily Norellinae Ager, 1959
Genus *Norella* Bittner, 1890

Type species: *Norella refractifrons* Bittner, 1890, p.315.

Norella kellneri Bittner, 1892

Fig. 7A, Pl. 1, figs A-D

1892 *Rhynchonella (Norella) Kellneri* spec. nov. Bittner: p. 25, pl. 3, figs 3-4.
1908 *Rhynchonella (Norella)* cf. *Kellneri* Bittner – Kittl: p. 482.
1910a *Rhynchonella (Norella) Kellneri* Bittner – Simionescu: p. 19, fig. 25, pl. 1, fig.18.

Material*:* Twelve specimens from the Bithynian of Agighiol, of which 10 are complete specimens: 3 figured specimens (LPB IIIb 800-802, Agighiol B2), 1 sectioned specimen (LPB IIIb 803, Agighiol B3), 1 complete specimen and 7 fragmentary specimens (LPB IIIb 804, AgighiolB2). Two complete specimens from the Bithynian of Orta Bair (LPB IIIb 805). One juvenile from the Aegean of Deşli Caira, layer 822A (LPB IIIb 806). Nine tiny complete specimens from the uppermost Spathian of Deşli Caira: layer 821, 1 figured specimen (LPB IIIb 807), layer 821, 2 additional specimens (LPB IIIb 808), layer 816, 6 specimens (LPB IIIb 809).

Description

External characters. Small norellid, subpentagonal in outline, equi-biconvex, gently sulciplicate. A faint incision is present in the posterior dorsal valve in the juvenile specimens. Beak recurved, deltidial plates not observed. Shell smooth.

Internal characters (Fig. 7A). Thick-shelled norellid, in which some details are obscured by crystallization. Ventral valve with rudimentary dental plates, supporting stout teeth, deeply inserted into the sockets, forming a robust articulation. Muscle fields well incised in transverse section. Median septum absent in the dorsal valve, with short and feeble hinge plates. Deep sockets with lateral accessory ridges. Hamiform crura.

Dimensions (in mm)

Specimen	Length	Width	Thickness
LPB IIIb 800	12.90	12.50	9.40
LPB IIIb 801	10.60	9.60	7.70
LPB IIIb 802	8.30	7.70	5.70
LPB IIIb 803	11.90	9.00	7.30
LPB IIIb 807	10.00	9.60	5.80
LPB IIIb 805/1	8.00	7.30	5.60
LPB IIIb 805/2	7.60	7.95	6.90

Remarks. *Norella kellneri* Bittner, 1892 is much smaller than all the other *Norella* species so far described. It differs from *N. refractifrons*, type

PLATE 1

Norella kellneri Bittner, 1892
Fig. A1-5 - specimen LPB IIIb 800. Dorsal, ventral, lateral, frontal, and posterior views, respectively. Agighiol B2, Bithynian.
Fig. B1-5 - specimen LPB IIIb 801. Dorsal, ventral, lateral, frontal, and posterior views, respectively Agighiol B2, Bithynian.
Fig. C1-5 - specimen LPB IIIb 802. Dorsal, ventral, lateral, frontal, and posterior views, respectively. Agighiol B2, Bithynian.
Fig. D1-5 - specimen LPB IIIb 807. Dorsal, ventral, lateral, frontal, and posterior views, respectively. Deşli Caira layer 821, Spathian.
Austriellula iordanae sp. n.
Fig. E1-5 - specimen LPB IIIb 810 holotype. Dorsal, ventral, lateral, frontal, and posterior views, respectively. Orta Bair, Bithynian.
Fig. F1-5 - specimen LPB IIIb 812. Dorsal, ventral, lateral, frontal, and posterior views, respectively. Deşli Caira, layer 828, Aegean.
Fig. G1-5 - specimen LPB IIIb 815. Dorsal, ventral, lateral, frontal, and posterior views, respectively. Deşli Caira, layer 821, Spathian.
Scale bar 1 cm.

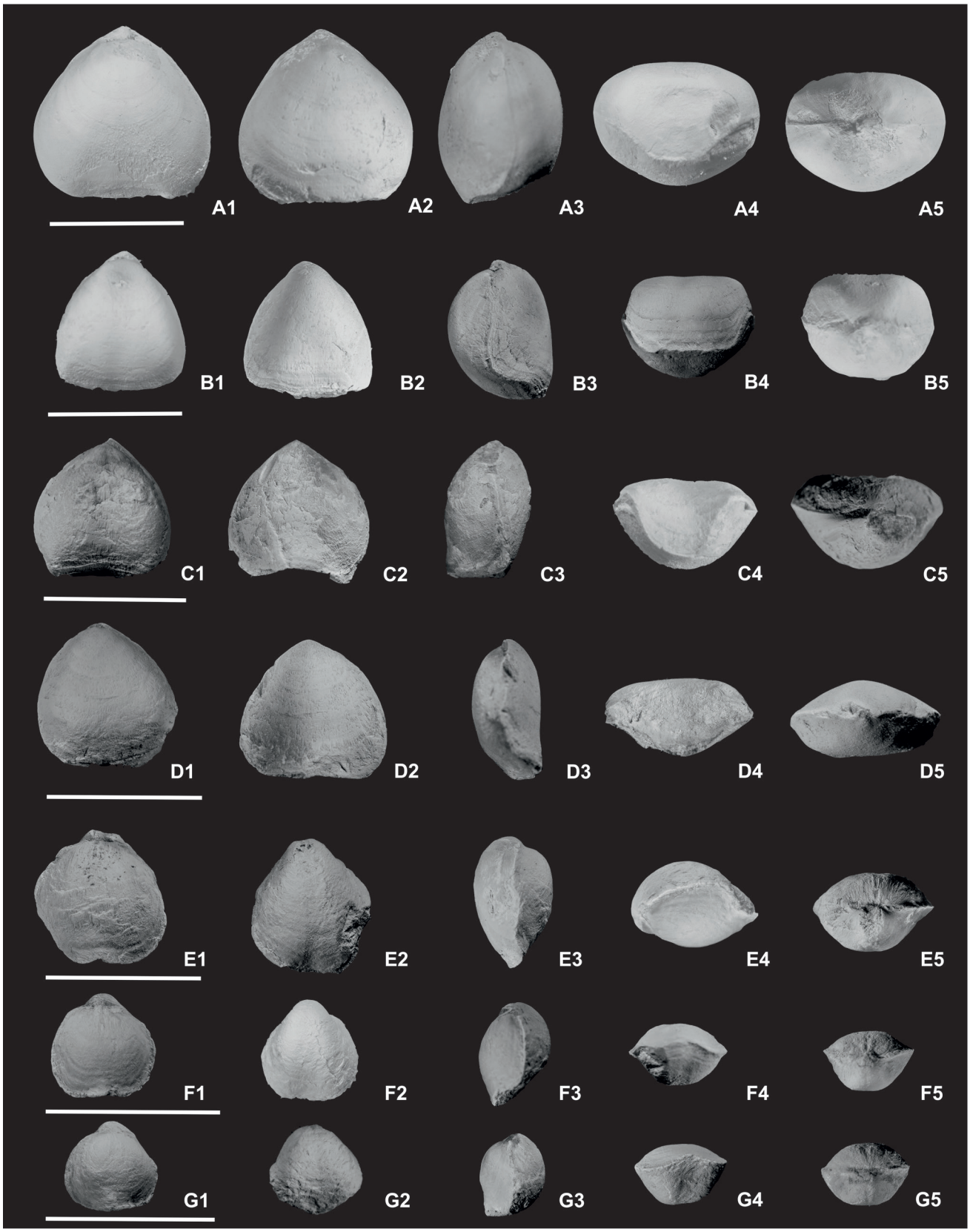
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PLATE 1

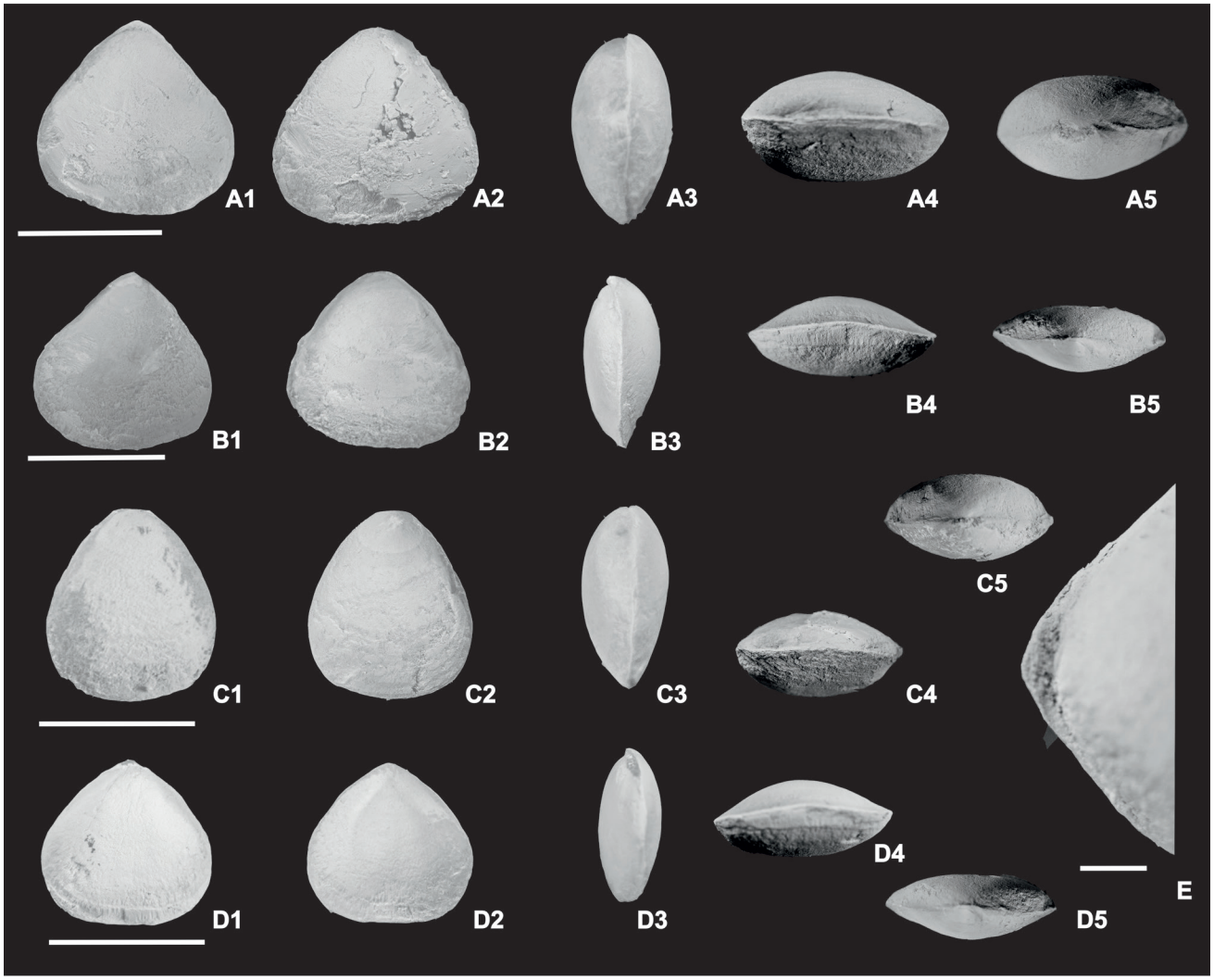

PLATE 2

Ortarhynchia petersi gen. n. sp. n.
Fig. A1-5 - specimen LPB IIIb 819 holotype. Dorsal, ventral, lateral, frontal, and posterior views, respectively. Orta Bair, Bithynian.
Fig. B1-5 - specimen LPB IIIb 820 paratype. Dorsal, ventral, lateral, frontal, and posterior views, respectively. Orta Bair, Bithynian.
Fig. C1-5 - specimen LPB IIIb 821 paratype. Dorsal, ventral, lateral, frontal, and posterior views, respectively. Orta Bair, Bithynian.
Fig. D1-5 - specimen LPB IIIb 822. Dorsal, ventral, lateral, frontal, and posterior views, respectively. Deşli Caira layer 821, Spathian.
Fig. E - specimen LPB IIIb 820. Detail of the umbo and foramen. Orta Bair, Bithynian.
Scale bar 1 cm.

species of the genus, in the more elongate and inflated shape, especially in the ventral valve, and has no faint plicae in the sinus. The species was firstly described from the Dinarids, without well-defined stratigraphic position. In North Dobrogea it was already described from Deşli Caira by Simionescu (1910a).

Occurrence. Deşli Caira, upper Spathian, layer 816 and loose blocks from layers 816 to 821; Deşli Caira, Aegean, layer 822A; Agighiol B2-B3 and Orta Bair, Bithynian.

Genus *Austriellula* Strand, 1928

Type species: *Rhynchonella dilatata* Suess, 1855; Dagys, 1974, p. 89, pl. 29, figs 8-9, text-fig. 57.

Austriellula iordanae sp. n.

Fig. 7B, Pl. 1, figs E-G

Derivation of name: Dedicated to Magdalena Iordan, who studied and illustrated the Triassic brachiopod fauna of Romania.

Type specimens: Holotype LPB IIIb 810), four paratypes (LPB IIIb 811), all from the Bithynian of Orta Bair.

Material: Other specimens: upper Spathian, Deşli Caira, la-

yer 810, 3 specimens (LPB IIIb 816), layer 811, 2 specimens (LPB IIIb 817), layer 821, 1 figured specimen (LPB IIIb 815), 1 additional specimen (LPB IIIb 818); Aegean, Deşli Caira, layer 828, 1 figured specimen (LPB IIIb 812), 1 sectioned specimen (LPB IIIb 813), and 5 additional specimens (LPB IIIb 814).

Diagnosis: Small sized shell, uniplicate, smooth. Thick shelled, with dental plates fused inside the callus. Laminar crura.

Description

External characters. Very small sized shell, subrounded in outline, with maximum thickness in the posterior part. Feebly uniplicate. Ventral valve forming ¾ of the total thickness. Dorsal valve almost flat and with a feeble depression in the posterior part of the valve in some specimens. Shell smooth, but with growth lines evident in some specimens.

Internal characters (Fig. 7B). Thick-shelled ventral valve, with deep muscle impression. Dental plates fused inside the callus; therefore, the teeth appear as directly supported by the shell wall and obliquely inserted in the sockets. Strong cardinal process, oblique hinge plates, with elevated inner socket ridge and a short median septum, poorly visible inside the callosity of the shell. Laminar crura.

Dimensions (in mm)

Specimen	Length	Width	Thickness
LPB IIIb 810 holotype	8.40	8.60	5.10
LPB IIIb 811/1 paratype	7.40	7.25	5.30
LPB IIIb 811/2 paratype	7.00	6.80	5.00
LPB IIIb 812	6.20	6.10	4.15
LPB IIIb 815	5.75	6.20	4.50
LPB IIIb 814	6.00	6.40	3.90
LPB IIIb 818	4.25	4.90	3.90

Remarks. If the assignment to *Austriellula* is correct, this species is the oldest representative so far known for the genus. With *Austriellula* it shares the general shape, the thick internal callosity and the deep muscle impression. The very small size could be linked to the "Lilliput effect," which was typical of brachiopods during their recovery and radiation after the P/T mass extinction. Gaetani (2016) described *Austriellula kavakensis* (Arthaber, 1914) from the Bithynian of Gebze (Turkey). It is proportionally wider and less thick. Internally it has rudimentary dental plates. The genus is most widespread in the Upper Triassic, particularly in the Hallstatt facies (Siblik 1982), as it occurs in North Dobrogea.

Occurrence. Deşli Caira section, upper Spathian, layers 810, 811, and loose blocks from layers 816-821; Aegean, layer 828. Orta Bair, Bithynian.

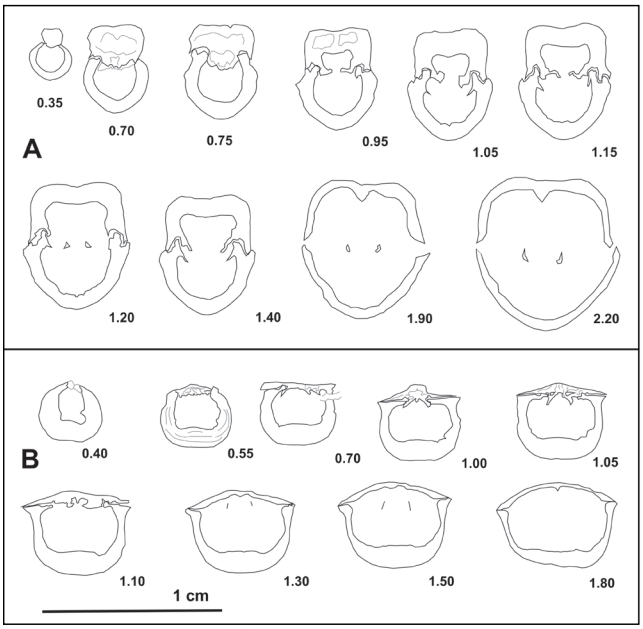

Fig. 7 - A) *Norella kellneri* Bittner, 1892 – Serial sections of the specimen LPB IIIb 803. Distance from the umbo in mm. Agighiol B3, Bithynian. B) A*ustriellula iordanae* sp. n. Serial sections of the specimen LPB IIIb 813. Distance from the umbo in mm. Deşli Caira, layer 828, Aegean.

Subfamily Paranorellininae Xu, 1990
Ortarhynchia gen. n.

Derivation of name: From the hill of Orta Bair in North Dobrogea.

Diagnosis: Equidimensional smooth brachiopod with small beak and foramen. Mostly rectimarginate. Thickened shell with callosity embedding both dental plates and septalium. No septum. Deeply incised muscle fields.

Content:. At present only the type species *Ortarhynchia petersi* gen. n. sp. n. is known. Upper Spathian and Anisian.

Ortarhynchia petersi gen. n. sp. n.

Fig. 8, Pl. 2, figs A-E

Derivation of name: In honour of Carl Ferdinand Peters, founder of the geological knowledge of North Dobrogea.

Type specimens: Holotype LPB IIIb 819, two figured paratypes (LPBIIIb 820 and 821); four other paratypes (LPB IIIb 825), all from Orta Bair, Bithynian.

Material: Other specimens: Bithynian, Agighiol B3, 1 specimen (LPB IIIb 830), Orta Bair, 1 sectioned specimen (LPB IIIb 823); Aegean, Deşli Caira, layer 822A, 7 specimens (LPB IIIb 829). Upper Spathian, Deşli Caira, layer 810, 1 specimen (LPB IIIb 822), layer 811, 1 specimen (LPB IIIb 826), layer 821, 1 sectioned specimen (LPB IIIb 824), 1 specimen (LPB IIIb 827), 1 specimen (LPB IIIb 828).

Description

External characters. Very small to small sized shell, subpentagonal to trigonal in outline, rectimarginate, smooth. The ventral valve has a small

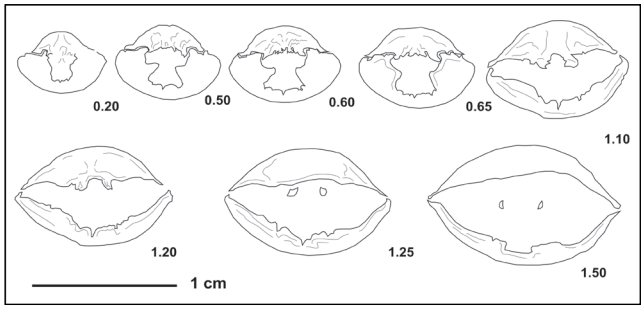

Fig. 8 - *Ortarhynchia petersi* gen. n. sp. n. Serial sections of the specimen LPB IIIb 823. Distance from the umbo in mm. Orta Bair, Bithynian.

sub-erect umbo, with a small foramen, hardly visible because of sediment infilling (Pl. 2, fig. E). Maximum thickness at mid-length.

Internal characters (Fig. 8). Very thick shell. In the ventral valve, dental plates merged to lateral wall. Stout and short teeth, with small denticula. Deeply incised muscle field. Well developed cardinal process in the dorsal valve, high inner socket ridges. A potential septalium is embedded in the callosity of the thickened shell, from which the crural basis emerges forward. No septum. Short crura.

Dimensions (in mm)

Specimen	Length	Width	Thickness
LPB IIIb 819 holotype	13.05	13.60	6.90
LPB IIIb 820 paratype	11.35	11.60	4.40
LPB IIIb 821 paratype	11.70	10.30	5.55
LPB IIIb 822	9.60	10.00	4.30
LPB IIIb 824	9.20	9.10	3.90
LPB IIIb 826	8.10	8.00	3.40
LPB IIIb 827	8.90	9.30	4.60
LPB IIIb 828	8.30	8.90	3.90
LPB IIIb 829	6.90	6.30	3.30
LPB IIIb 829	5.90	6.00	3.00
LPB IIIb 829	5.20	5.60	2.30
LPB IIIb 829	5.90	6.00	3.20
LPB IIIb 830	10.90	10.30	6.65

Remarks. The size of the shell is double in the Bithynian specimens vs the upper Spathian and Aegean specimens. The increase in size should be linked to the end of the "Lilliput effect". No similar brachiopod seems to have been described in the Olenekian and Anisian.

Occurrence. Deşli Caira, upper Spathian, layers 810, 811 and 821; Aegean, layer 822A; Agighiol B3 and Orta Bair, Bithynian.

Subfamily Holcorhynchellinae Dagys, 1974
Genus *Piarorhynchella* Dagys, 1974

Type species: *Piarorhynchella mangyshlakensis* Dagys, 1974, p. 110, pl. 32, figs 8-10, text-fig. 75.

Piarorhynchella kittli sp. n.

Fig. 9, Pl. 3, figs A-E

Derivation of name: In honour of Ernst Kittl, who first extensively described the Triassic of North Dobrogea.

Type specimens: Holotype LPB IIIb 869; eight paratypes (LPB IIIb 831-835, LPB IIIb 870), all from Mahmudia, Bithynian.

Material: Other specimens: Bithynian, Mahmudia, 4 isolated valves (LPB IIIb 836).

Description

External characters. Small sized uniplicate rhynchonellid, wider than longer, strong sub-erect beak; maximum thickness at ¾ of the length, fold and sulcus starting at middle length. The dorsal valve has a significant depression in the early stage of ontogeny, then it is uniplicate with the fold showing a triangular contour. Fold slightly recumbent at the front. The ventral valve shows a low bulge posteriorly, passing forward to a deep sulcus, with a triangular shape.

PLATE 3

Piarorhynchella kittli sp. n.
Fig. A1-5 - specimen LPB IIIb 869 holotype. Ventral, dorsal, lateral, frontal, and posterior views, respectively.
Fig. B1-5 - specimen LPB IIIb 831 paratype. Ventral, dorsal, lateral, frontal, and posterior views, respectively.
Fig. C1-5 - specimen LPB IIIb 832 paratype. Ventral, dorsal, lateral, frontal, and posterior views, respectively.
Fig. D1-5 - specimen LPB IIIb 833 paratype. Ventral, dorsal, lateral, frontal, and posterior views, respectively.
Fig. E1-5 - specimen LPB IIIb 834 paratype. Ventral, dorsal, lateral, frontal, and posterior views, respectively.
The Mahmudia quarry, Bithynian.
Costirhynchopsis sp. A.
Fig. F1-4 - specimen LPB IIIb 837. Ventral, dorsal, lateral, and frontal views, respectively. Deşli Caira, layer 830, Aegean.
Costirhynchopsis sp. B.
Fig. G1-3 - specimen LPB IIIb 838. Ventral, lateral and frontal views, respectively.
The Mahmudia quarry, Bithynian.
Costirhynchopsis sp. C.
Fig. H1-5 - specimen LPB IIIb 873. Ventral, dorsal, lateral, frontal and posterior views, respectively.
The Mahmudia quarry, Bithynian.
Scale bar 1 cm.

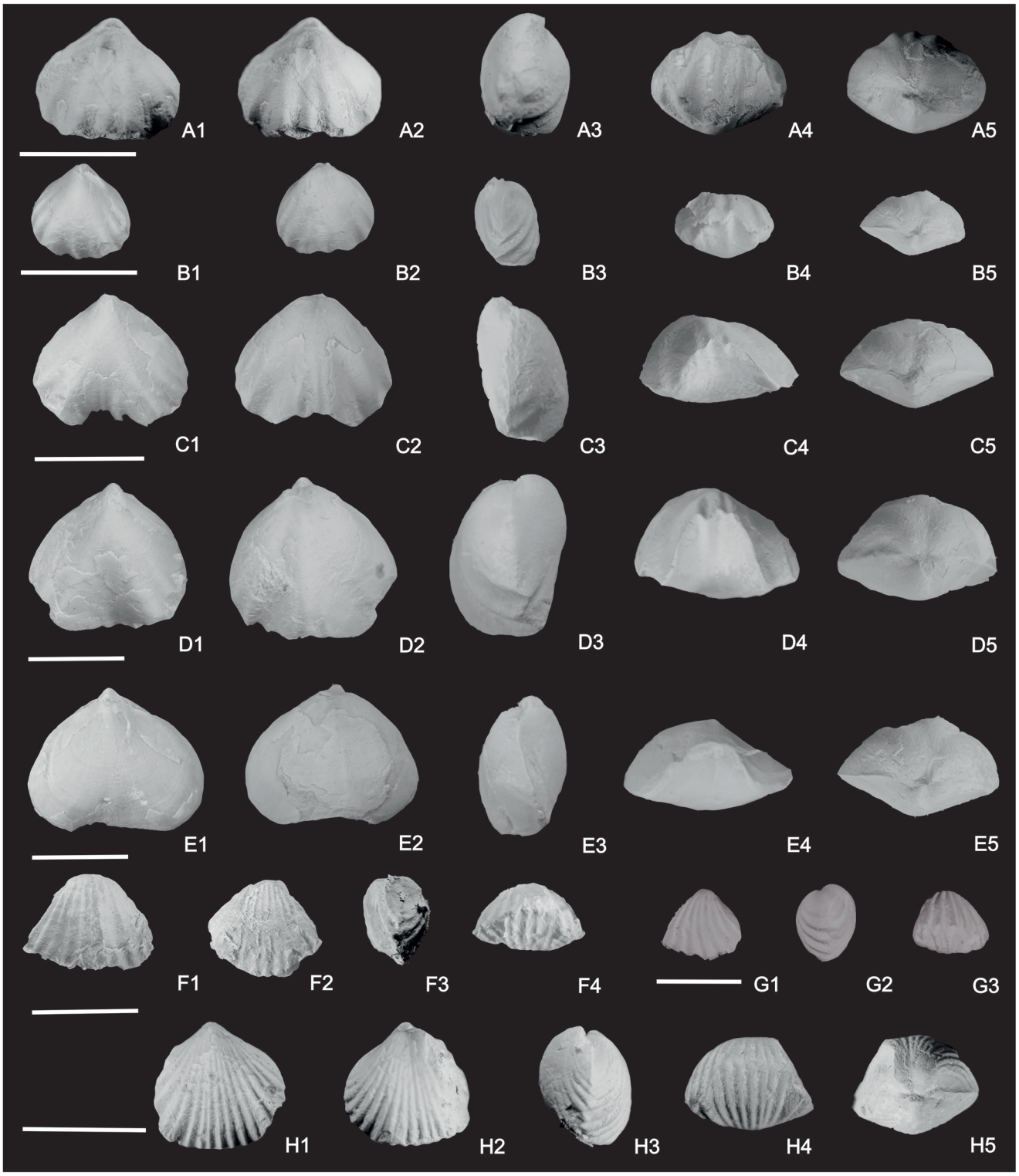
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PLATE 3

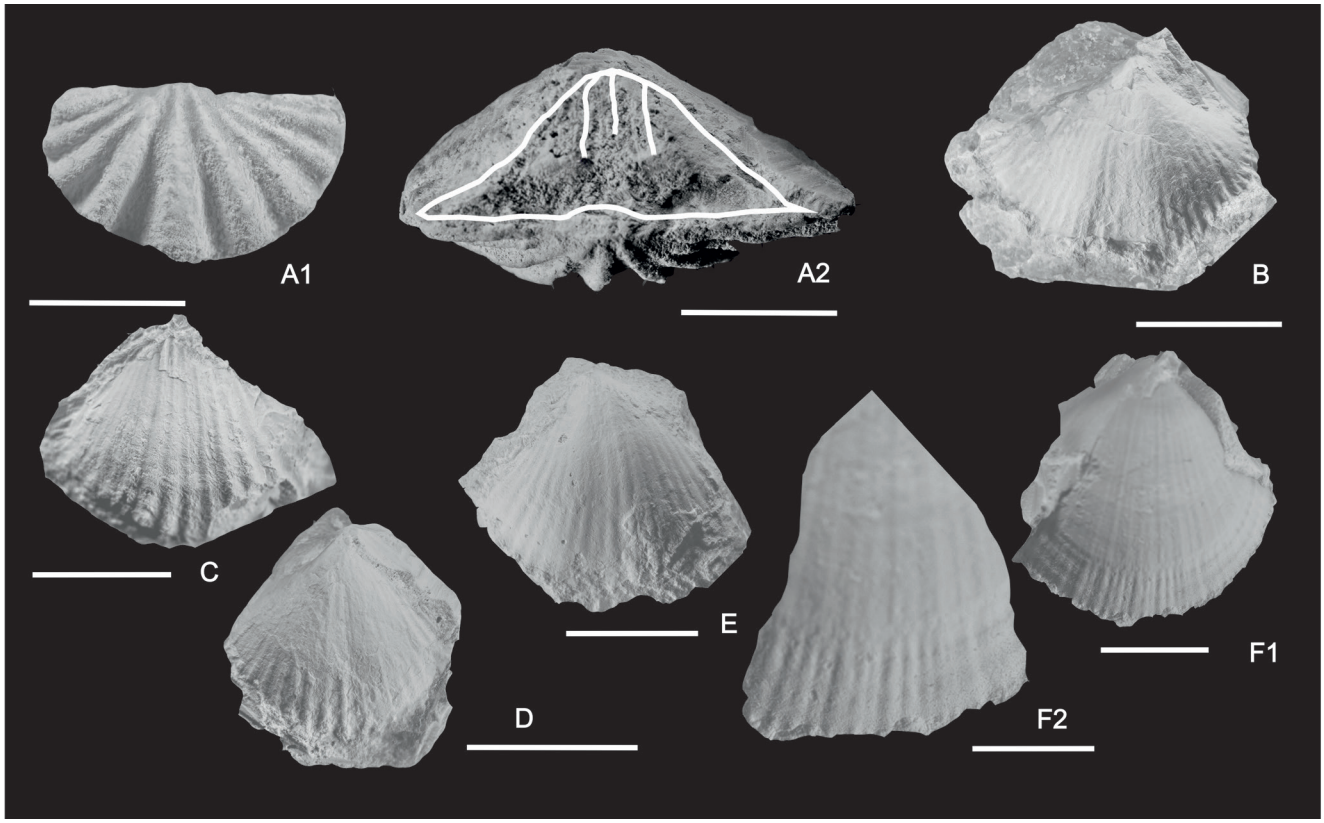

PLATE 4

Punctospirella sp. ind.
Fig. A1-2 - specimen LPB IIIb 839. Dorsal view and posterior views, with traced dental plates, respectively.
The Mahmudia quarry, Bithynian.
? *Dinarispira* sp. ind.
Fig. B - specimen LPB IIIb 840. Ventral view.
Fig. C - specimen LPB IIIb 841. Ventral view.
The Mahmudia quarry, Bithynian.
Koeveskallina sp. A
Fig. D - specimen LPB IIIb 842. Ventral view.
Fig. E - specimen LPB IIIb 843. Ventral view.
The Mahmudia quarry, Bithynian.
Koeveskallina sp. B
Fig. F1-2 - specimen LPB IIIb 846. Ventral view and magnification of the ornamentation with the dichotomy of the costae.
The Mahmudia quarry, Bithynian.
Scale bar 1 cm.

Shell smooth in the posterior part, then with rounded costae in the half-anterior part, 2/3 in the middle, 3/2 on the flanks. In some specimens, especially juvenile, the surface is almost smooth, with indentation present only along the frontal commissure. Peculiar is the tendency to have an asymmetrical development or to duplicate the median costae.

Internal characters (Fig. 9). Heavy recrystallization prevents accurate descriptions. Dental plates, septalium, and median short septum are recognized.

Dimensions (in mm)

Specimen	Length	Width	Thickness
LPB IIIb 869 holotype	11.40	13.50	9.30
LPB IIIb 831 paratype	9.90	10.50	7.30
LPB IIIb 832 paratype	10.30	12.70	9.20
LPB IIIb 833 paratype	13.50	13.70	7.60
LPB IIIb 834 paratype	13.60	16.30	9.50
LPB IIIb 835 paratype	13.20	14.80	10.10
LPB IIIb 870/1	9.70	10.90	6.65
LPB IIIb 870/2	11.80	11.90	9.55
LPB IIIb 870/3	13.15	15.90	10.20

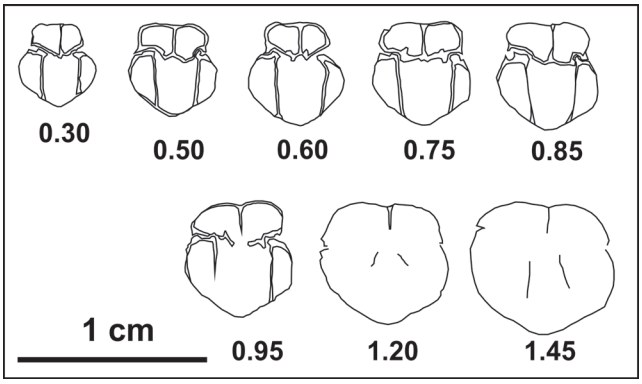

Fig. 9 - *Piarorhynchella kittli* sp. n. Serial sections of the specimen LPB IIIb 835. Distance from the umbo in mm. The Mahmudia quarry, Bithynian.

Remarks. The North Dobrogea specimens have some characters of *Piarorhynchella* and others approach those of *Holcorhynchella*. If compared with other species of *Piarorhynchella, P. kittli* sp. n. has the general shape, wider than longer, and the costae. From *P. mangyshlakensis* Dagys, 1974 it differs in the dimensions, the presence of a depressed area in the posterior part of the dorsal valve, and the irregularity of the median costae. The species from the Spathian of Mangyshlak is probably still under the "Lilliput "effect (Zakharov & Popov 2014). From the genus *Holcorhynchella* and its numerous species from Dalmatia, *P. kittli* sp. n. differs in the wider contour, higher number of costae and the wider, deep sulcus.

Occurrence. The Mahmudia quarry, *Tubiphytes*-boundstone, layer 114, Bithynian.

Superfamily Hemithyridoidea Rzhonsnitskaya, 1956
Family Cyclothyrididae Makridin, 1955
Genus *Costirhynchopsis* Dagys, 1977

Type species: *Costirhynchia spatiosa* Dagys, 1974, p.106, pl. 31, fig. 10, text-fig.69.

Remarks. Under this heading, I report three specimens of costate rhynchonellids, different from each other, for which the actual species attribution is doubtful.

Costirhynchopsis sp. A

Pl. 3, figs F1-4

Material. One almost complete specimen (LPB IIIb 837).

Description

External characters. Small biconvex unipli-cate shell, with sub-pentagonal outline forming an apron. Fold and sulcus developed from one third of the length. Fully costate, with sharp angular costae, starting from the umbonal region, 4/5 on sulcus and fold, 5/4 on each flank. The frontal commissure is arcuate, and the costae may occur on the flank of the sulcus.

Internal characters. The dental plates may be observed on the fractured ventral umbo.

Dimensions (in mm): length >9.60, width 12.90, thickness 8.10.

Remarks. The general shape recalls the nominative species of *Costirhynchopsis, C. spatiosa* (Dagys, 1974) from the Carnian deposits of the Caucasus.

Occurrence. Deşli Caira, Aegean, layer 830.

Costirhynchopsis sp. B

Pl. 3, figs G1-3

Material: One incomplete specimen (LPB IIIb 838).

Description. Small biconvex shell, with sub-pentagonal outline, uniplicate. Fold and sulcus developed from mid-length. Fully costate, with sharp angular costae, starting from the umbonal region. The specimen has 3/4 costae on sulcus and fold, and 5/4 on each flank.

Remarks. The attribution to *Costirhynchopsis* is tentative. Some characters approach *C. mentzeli* (Buch, 1843).

Occurrence. The Mahmudia quarry, *Tubiphytes*-boundstone, layer 114, Bithynian.

Costirhynchopsis sp. C

Pl. 3, figs H1-5

Material: One complete specimen (**LPB IIIb** 873), one incomplete specimen (LPB IIIb 879).

Description. Small biconvex uniplicate shell, with sub-rounded outline. Sub-erect beak. Sulcus gently depressed from the middle of the length. Low depression in the posterior part of the dorsal valve, then gently elevated fold. Maximum thickness at the middle of the length. Fully costate, with thin angular costae on the whole surface; 6/7 in the median region, and 5/4 on each flank.

Remarks. The costal pattern recalls *C. orientalis* (Peters, 1867) from the Norian of the island of Popina in North Dobrogea. However, the outline of the shell in that species is wider, forming an apron.

Dimensions (in mm): length 10.50, width >10.90, thickness 7.90.

Occurrence. The Mahmudia quarry, *Tubiphytes*-boundstone, layer 114, Bithynian.

Order **Spiriferinida** Ivanova, 1972
Suborder **Spiriferinidina** Ivanova, 1972
Superfamily Pennospiriferinoidea Dagys, 1972
Family Punctospirellidae Dagys, 1974
Genus *Punctospirella* Dagys, 1974

Type species: *Terebratula fragilis* Schlotheim, 1814; Dagys, 1974, p. 136, pl. 39, figs 2-3, text-fig. 91.

Punctospirella sp. ind.

Pl. 4, figs A1-2

Material: One specimen (LPB IIIb 839) represented by a dorsal valve and part of the ventral valve.

Description. Small uniplicate spiriferinid, wider up to double of the length, with obtuse cardinal extremities. Apsacline interarea.

Smooth fold and sulcus, 4 rounded and stout costae on each flank, extended over all of the surface.

The partial abrasion of the interarea allows observation of the dental plates well separated with a median septum as deep as half of the plates (Pl.4, fig. A2).

Dimensions (in mm): length 11.30; width 18.5; thickness 10.20.

Remarks. The external shape perfectly matches the holotype of *Nudispiriferina minima* Yang & Xu, 1966. However, the well separated and extended dental plates approach much more to the species of the genus *Punctospirella.*

Occurrence. The Mahmudia quarry, *Tubiphytes*-boundstone, layer 114, Bithynian.

Genus *Dinarispira* Dagys, 1974

Type species: *Spiriferina pia* var. *dinarica* Bittner, 1890; Dagys, 1974, p. 131, pl. 37, fig. 8, text-fig. 88.

? Dinarispira sp. ind.

Pl. 4, figs B-C

Material: Four incomplete ventral valves (LPB IIIb 840-841, LPB IIIb 847 and 877).

Description. Medium sized spiriferinid, as long as wide, gently curved, with three costae in the sulcus and 6-7 on the flanks. Apsacline interarea.

Dimensions (in mm): length > 17, width 19.5.

Remarks. These specimens are tentatively referred to the genus *Dinarispira,* for the median septum is partly visible on the surface of the shell. Instead, the dental plates seem to be absent.

Occurrence. The Mahmudia quarry, *Tubiphytes*-boundstone, layer 114, Bithynian.

Superfamily Mentzelioidea Dagys, 1974
(*nom. transl.* Sun & Ye, 1982)

For the discussion of the suprageneric classification of mentzeliids, refer to Gaetani & Mantovani (2015).

Family Mentzeliidae Dagys, 1974
(*nom. transl.* Sun & Ye, 1982)
Genus *Koeveskallina* Dagys, 1965

Type species: *Koeveskallina koeveskalyensis* (Stur, 1865); Dagys, 1965, p. 172; Dagys, 1974, p. 140, pl. 40, figs 3-4, text-fig. 94.

Koeveskallina sp. A

Fig. 10, Pl. 4, figs D-E

Material: Five ventral valves (LPB IIIb 842-844 and 871) and 3 dorsal valves (LPB IIIb 845).

PLATE 5

Ptychomentzelia dobrogeana sp. n.
Fig. A1-5 - specimen LPB IIIb 849 paratype. Ventral, dorsal, lateral, frontal, and posterior views, respectively.
Fig. B1-5 - specimen LPB IIIb 848, paratype. Ventral, dorsal, lateral, frontal, and posterior views, respectively.
Fig. C1-5 - specimen LPB IIIb 872, holotype. Ventral, dorsal, lateral, frontal, and posterior views, respectively.
Fig. D1-5 - specimen LPB IIIb 850, paratype. Ventral, dorsal, lateral, frontal, and posterior views, respectively.
Fig. E - specimen LPB IIIb 851 paratype. Ventral view.
Fig. F - specimen LPB IIIb 852, paratype. Ventral view.
Fig. G1-2 - specimen LPB IIIb 853 paratype. Ventral and dorsal views, respectively.
The Mahmudia quarry, Bithynian.
Ptychomentzelia simionescui sp. n.
Fig. H1- 5 - specimen LPB IIIb 851, holotype. Ventral, dorsal, lateral, frontal, and posterior views, respectively.
The Mahmudia quarry, Bithynian.
Scale bar 1 cm.

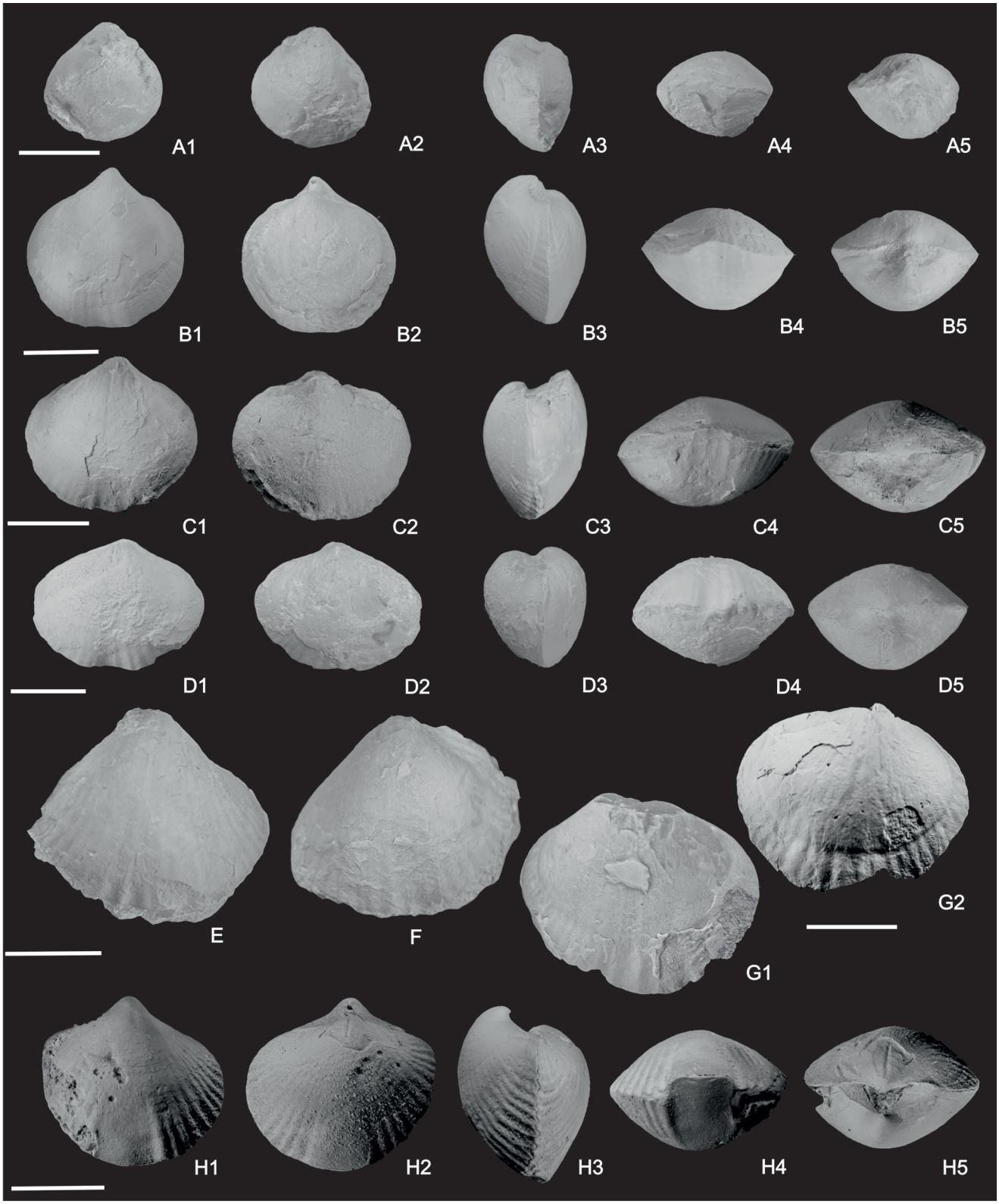
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PLATE 5

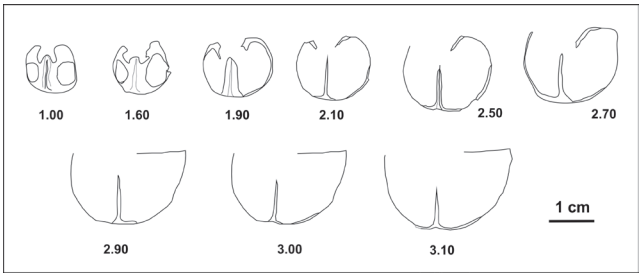

Fig. 10 - *Koeveskallina* sp. A. Serial sections of the specimen LPB IIIb 844. Distance from the umbo in mm. The Mahmudia quarry, Bithynian.

Description. Small sized mentzeliid, with rounded outline. The sulcus is only gently defined, with rounded flanks. The whole surface is covered by thin costae, three in the sulcus and about 8-10 on each flank. Median septum length at least 1/3 of the total length. Dental flanges attached at the end of the septum, teeth supported by the wall of the valve (Fig. 10).

Dimensions (in mm): length 16.50, width 19.80, thickness of the ventral valve about 10 mm.

Remarks. This species differs from *K. koeveskalyensis* (Stur, 1865) in the lesser number of costae, the sulcus being better defined and the less globose shape. From *K. pannonica* (Bittner) it differs in the number of costae on the flanks.

Occurrence. The Mahmudia quarry, *Tubiphytes*-boundstone, layer 114, Bithynian.

Koeveskallina sp. B

Pl. 4, figs F1-2

Material: Two ventral valves (LPB IIIb 846 and LPB IIIb 878).

Description. This specimen has the general shape of *Koeveskallina*, with thin costae over all of the surface of the shell. However, the costae have an unusual pattern. The more prominent are twin costae between which are intercalated thinner single costae that appear at some distance from the umbo. For this reason, it is kept separate. I am not aware of this kind of ornament in other *Koeveskallina* species.

Occurrence. The Mahmudia quarry, *Tubiphytes*-boundstone, Bithynian.

Genus *Ptychomentzelia* Gaetani & Mantovani, 2015

Type species: *Spiriferina (Mentzelia) Mentzelii* var. *propontica* Toula, 1896, p. 159, pl.18, fig. 7a-e.

Ptychomentzelia dobrogeana sp. n.

Fig. 11, Pl. 5, figs A-G

Derivation of name: From the Dobrogea region.

Type specimens: Holotype LPB IIIb 872, 6 figured paratypes (LPB IIIb 848-853), 1 sectioned paratype (LPB IIIb 854), all from Mahmudia, Bithynian.

Material*:* Other specimens: LPB IIIb 855 and 876, 21 nearly complete specimens and 34 isolated valves, 28 ventral and 6 dorsal.

Description

External characters. Medium to large sized mentzeliid, usually wider than long. Feebly uniplicate. The ventral valve shows a feeble narrow sulcus in the anterior half, with rounded flanks. The dorsal valve has a very feeble fold.

Ornament consists of very feeble costae, often poorly visible on the internal mould, present in the anterior part, 2-3 on the fold and sulcus, and 4-5 on the flanks.

Internal characters (Fig. 11). Ventral valve with simple median septum that extends for 1/3 of the total length. Divergent dental plates, originating by the fusion of adminicula and dental flanges. Teeth small, deeply inserted in the sockets. Dorsal valve with high cardinal process, very short median septum, thinning out in a myophragm anteriorly. Horizontal hinge plates, with high inner socket ridges. Laminar diverging crural bases. Spiralium not preserved.

PLATE 6

Adygella sp. ind.
Fig. A1-5 - specimen LPB IIIb 859. Ventral, dorsal, lateral, frontal, and posterior views, respectively.
The Mahmudia quarry, Bithynian.
Rhaetina sp. ind.
Fig. B1-5 - specimen LPB IIIb 861. Ventral, dorsal, lateral, frontal, and posterior views, respectively.
The Mahmudia quarry, Bithynian.
Sulcatinella aff. *S. incrassata* (Bittner, 1890)
Fig. C1-5 - specimen LPB IIIb 862. Ventral, dorsal, lateral, frontal, and posterior views, respectively.
Fig. D1-5, specimen LPB IIIb 863. Ventral, dorsal, lateral, frontal, and posterior views, respectively.
Fig. E1-5 - specimen LPB IIIb 864. Ventral, dorsal, lateral, frontal, and posterior views, respectively.
Fig. F1-5 - specimen LPB IIIb 865. Ventral, dorsal, lateral, frontal, and posterior views, respectively.
The Mahmudia quarry, Bithynian.
Scale bar 1 cm.

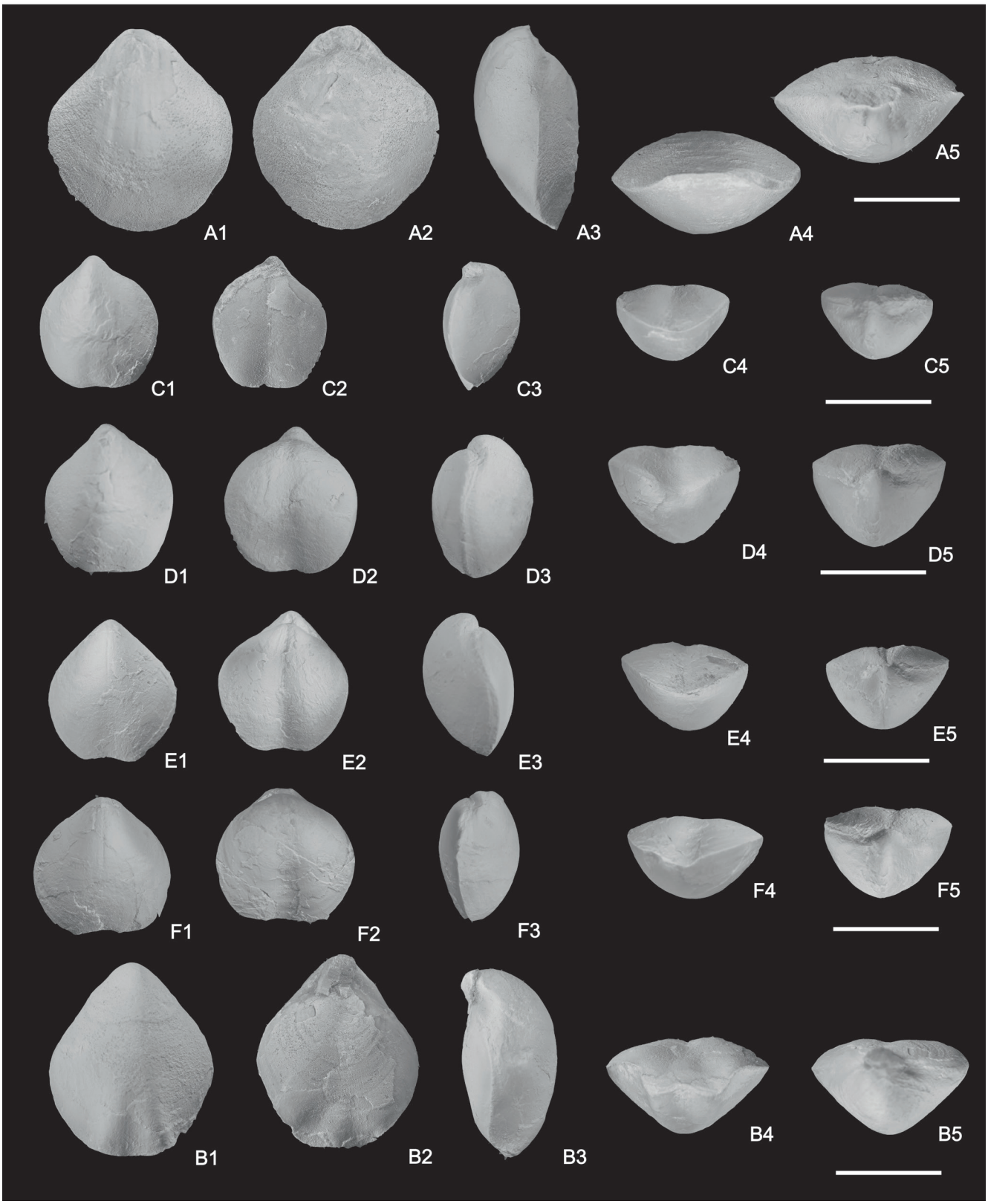
A1
A2
A3
A4
A5
C1
C2
C3
C4
C5
D1
D2
D3
D4
D5
E1
E2
E3
E4
E5
F1
F2
F3
F4
F5
B1
B2
B3
B4
B5

PLATE 6

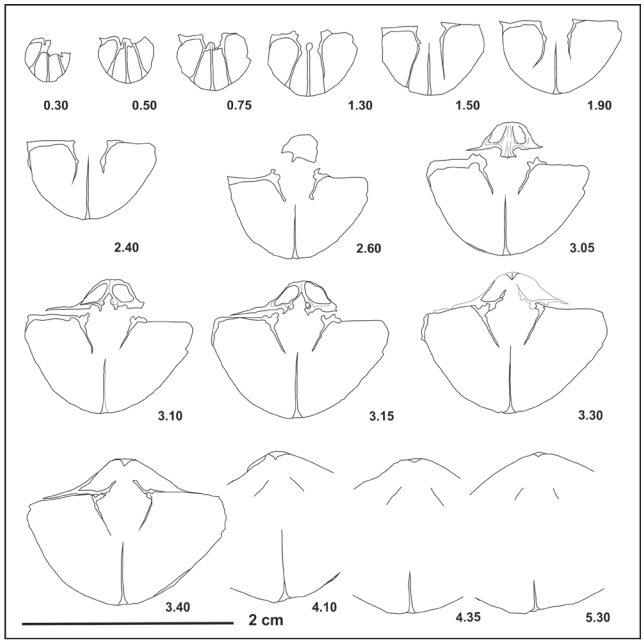

Fig. 11 - *Ptychomentzelia dobrogeana* sp. n. - Serial sections of the specimen LPB IIIb 854. Distance from the umbo in mm. The Mahmudia quarry, Bithynian.

Dimensions (in mm)

Specimen	Length	Width	Thickness
LPB IIIb 872 holotype	19.80	23.45	14.45
LPB IIIb 848 paratype	14.20	13.90	10.40
LPB IIIb 849 paratype	17.10	22.00	14.60
LPB IIIb 850 paratype	22.55	27.10	13.60
LPB IIIb 851 paratype	22.20	27.50	13.40
LPB IIIb 852 paratype	------	27.60	17.90
LPB IIIb 853 paratype	19.40	19.20	13.40

Discussion. The general shape is similar to *Ptychomentzelia propontica* (Toula, 1896). However, the sulcus is narrow and not so triangularly shaped and open as in *P. propontica*. The short septum supporting a septalium does not occur in *P. propontica*.

Occurrence. The Mahmudia quarry, *Tubiphytes*-boundstone, layer 114, Bithynian.

Ptychomentzelia simionescui sp. n.

Fig. 12, Pl. 5, figs H1-5

Derivation of name: In honor of Ion Simionescu, who significantly contributed to the study of the Triassic deposits of North Dobrogea.

Type specimens: Holotype LPB IIIb 856, 2 paratypes sectioned (LPB IIIb 857, partially complete, and LPB IIIb 858, ventral valve).

Material: Other specimens: 6 ventral valves and 1 dorsal valve (LPB IIIb 859).

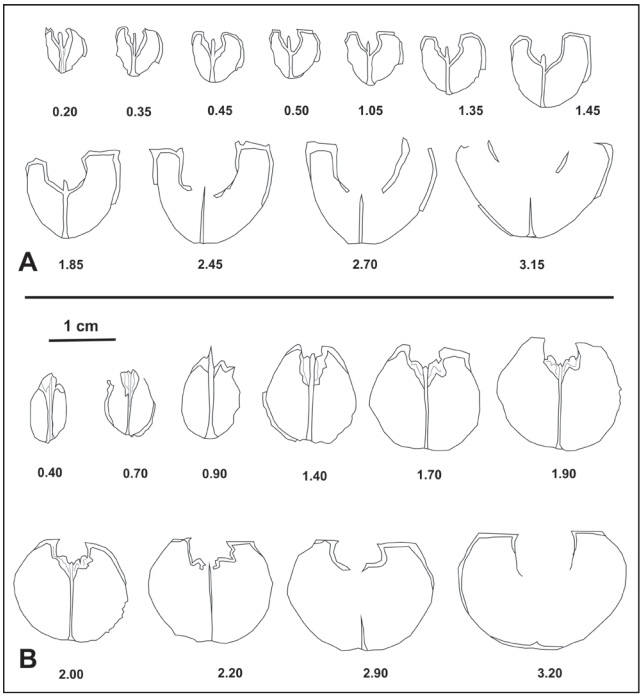

Fig. 12 - *Ptychomentzelia simionescui* sp. n. A- Serial sections of the specimen LPB IIIb 857. B - Serial sections of the specimen LPB IIIb 858. Distance from the umbo in mm. The Mahmudia quarry, Bithynian.

Description

External characters. Small sized mentzeliid, feebly uniplicate, as wide as long, with maximum width before the middle length. Small recurved apsacline interarea. The sulcus is only gently incised and appears smooth, and the fold is not elevated. On the flanks, there are 9-10 faint costae, starting almost from the umbo.

Internal characters (Fig. 12). Ventral valve with median septum, to which are attached the curved dental flanges. The median septum extends for about 2/5 of the total length. Strong teeth inserted obliquely in the sockets. Dorsal valve with median septum, stout at the base.

Dimensions (in mm): Holotype: length 16.60, width 17.10, thickness 11.60.

Discussion. This species is similar in shape to *Ptychomentzelia ptychitiphila* (Bittner, 1890), from which it differs in the flat and less developed sulcus and fold, and the higher number of costae on the flanks. *P. simionescui* sp. n. differs from *P. dobrogeana* sp. n. in size and in having a sulcus and fold that are smooth, without costae.

Occurrence. The Mahmudia quarry, *Tubiphytes*-boundstone, layer 114, Bithynian.

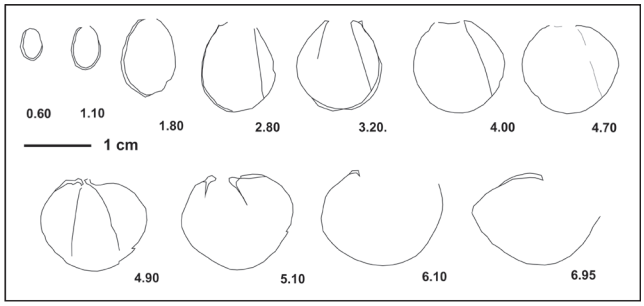

Fig. 13 - *Adygella* sp. ind. Serial sections of the specimen LPB IIIb 860. Distance from the umbo in mm. The Mahmudia quarry, Bithynian.

Order **Terebratulida** Waagen, 1883
Suborder **Terebratulidina** Waagen, 1883
Superfamily Dielasmatoidea Schuchert, 1913
Family Dielasmatidae Schuchert, 1913
Subfamily Dielasmatinae Schuchert, 1913
Genus *Adygella* Dagys, 1959

Type species: *Adygella cubanica* Dagys, 1959: 25; Dagys, 1974, 172, pl. 46, fig.1, text-figs 117-118.

Adygella sp. ind.

Fig. 13, Pl. 6, figs A1-5

Material: One complete specimen (LPB IIIb 859) and a fragment of a ventral valve (LPB IIIb 860, sectioned).

Description

External characters. Sub-pentagonal elongate contour, with maximum thickness in the posterior part of the shell. Umbo recurved, but partly broken. Gently uniplicate. Shell smooth with faint growth lines. Muscle field in the ventral valve with rounded diductors and adductor scars elongate till the middle length of the valve.

Internal characters (Fig. 13). No pedicle collar. Extremely thin convergent dental plates. Teeth small, supported by the shell wall.

Dimensions (in mm): length 20.00, width 18.10, thickness 10.10.

Discussion. The general shape of this species recalls the genus *Coenothyris* Douvillè, 1879, but the presence of the dental plates suggests the attribution to the genus *Adygella* Dagys, 1959.

Occurrence. The Mahmudia quarry, *Tubiphytes*-boundstone, layer 114, Bithynian.

Genus Sulcatinella Dagys, 1974

Type species: *Sulcatinella sulcata* Dagys, 1974, p. 178, pl. 46, fig.5, text-figs 122-123.

Sulcatinella aff. ***S. incrassata*** (Bittner, 1890)

Figs 14, 15, Pl. 6, figs C-F

Material: One of the two most abundant species in the assemblage under study. Twenty-five bivalved specimens and 18 incomplete. Four figured specimens (LPB IIIb 862- 865), 1 sectioned specimen (LPB IIIb 866), 20 measured specimens (LPB IIIb 867), 3 measured specimens (LPB IIIb 874).

Description

External characters. Small sized, sulciplicate dielasmatid, pentagonal in outline, slightly wider than long. Ventral valve inflated and convex, at least double the thickness of the dorsal valve. Greatest width and thickness attained around the mid-length. Dorsal valve with large and stout beak, straight and pointed in some specimens, curved in others. Straight beak ridges. Foramen partially occluded, especially in the thicker specimens. In the dorsal valve, the sulcus is starting near the dorsal umbo, forming an acute apron at the front, with rounded shoulders. Shell smooth.

Internal characters (Fig. 14). Ventral valve with short dental plates, near to the flanks, leaving a broad delthyrial cavity. Septalium deep, hinge plate in low position. Inner socket ridges prominent. Teeth inserted obliquely, sided by small denticle. The median septum reaches half of entire length.

Dimensions (in mm)

Specimen	Length	Width	Thickness
LPB IIIb 862	13.60	10.90	8.00
LPB IIIb 863	13.60	11.10	9.20
LPB IIIb 864	13.60	12.30	8.60
LPB IIIb 867	13.50	10.60	8.60
LPB IIIb 865	13.40	13.20	7.70
LPB IIIb 867	11.60	11.20	6.90
LPB IIIb 867	11.70	8.80	7.30
LPB IIIb 867	12.30	10.90	6.80
LPB IIIb 867	12.40	12.50	7.70
LPB IIIb 867	13.60	11.30	9.30
LPB IIIb 867	13.90	11.00	9.90
LPB IIIb 867	10.90	10.50	6.70
LPB IIIb 867	8.10	8.90	3.90
LPB IIIb 867	16.15	9.10	7.45
LPB IIIb 867	9.80	8.30	6.20
LPB IIIb 867	10.90	8.80	7.10
LPB IIIb 867	11.60	12.00	8.10
LPB IIIb 867	11.45	10.90	7.60
LPB IIIb 867	13.10	12.15	9.30
LPB IIIb 867	10.70	9.60	6.50
LPB IIIb 867	13.60	12.40	9.20
LPB IIIb 867	11.40	11.00	6.60
LPB IIIb 874	14.10	12.60	8.00
LPB IIIb 874	------	19.40	10.60
LPB IIIb 874	17.20	15.10	13.60

Discussion. The species of *Sulcatinella* under

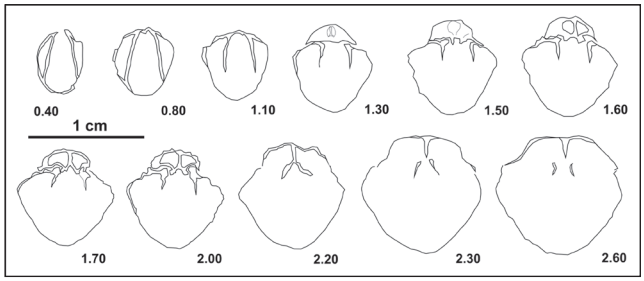

Fig. 14 - *Sulcatinella* aff. *S. incrassata* (Bittner, 1890). Serial sections of the specimen LPB IIIb 866. Distance from the umbo in mm. The Mahmudia quarry, Bithynian.

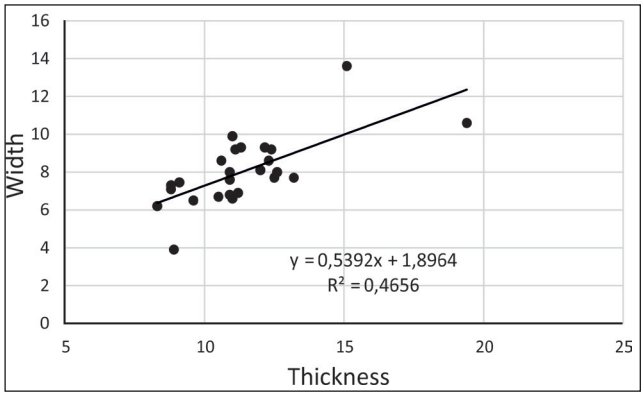

Fig. 15 - Scatter plot of width versus thickness (in mm) of 25 specimens of *Sulcatinella* aff. *S. incrassata* (Bittner, 1890). The Mahmudia quarry, Bithynian.

exam differs from the type-species of the genus, *S. sulcata* Dagys, 1974, for the less deep sulcus, starting near the dorsal umbo, and for the rounder shoulders of the sulcus itself. Some specimens are thicker, with recurved beak even if they are still small. Others specimens are longer with erect beak and are less thick. *Sulcatinella incrassata* (Bittner, 1890) is proportionally longer and thicker, with more rounded contour (Bittner, 1890, pl. 41, figs. 23-26) whilst the specimens described by Palfy (2003) are more pentagonal in outline. Therefore, the Mahmudia specimens are considered as only *affinis* to the *incrassata* species.

Occurrence. The Mahmudia quarry, *Tubiphytes*-boundstone, layer 114, Bithynian.

Family Angustothyrididae Dagys, 1972

Genus *Rhaetina* Waagen, 1883

Type species: *Terebratula gregaria* Suess, 1854; Dagys, 1963: p.142: Dagys, 1974: p. 175, pl. 46, fig. 3.

***Rhaetina* sp. ind.**

Pl. 6, figs B1-5

Material: One complete specimen (LPB IIIb 861) and one fragmentary specimen (LPB IIIb 875).

Description. Olive shaped dielasmatid of middle size. The ventral valve is thicker than the dorsal, maximum width and thickness at mid-length. A gently elevated fold divides anteriorly into two plicae, forming a sulciplicate anterior commissure. The ventral valve has a sulcus starting from the umbo, in which anteriorly a faint plica emerges. Shell smooth.

Dimensions (in mm): length 18.40, width 15.60, thickness 8.10.

Discussion. The specimen is tentatively referred to the genus *Rhaetina* Waagen, 1882, with which it shares the double fold in the ventral valve. However, *Rhaetina* has a non-depressed posterior part of the dorsal valve and lacks the small plica near the front of the dorsal valve.

This pattern is similar to the species of *Sichuanothyris* Shen, He & Zhu, 1992 of the Changhsingian of southern China. *Sulcatinella* Dagys, 1974

Order **RHYNCHONELLIDA** Kuhn, 1949	
Family **Norellidae** Ager, 1959	
Subfamily Norellinae Ager, 1959	
Norella kellneri (Bittner, 1892)	24
Austriellula iordanae sp. n.	19
Subfamily Paranorellininae Xu, 1990	
Ortarhynchia petersi gen n. sp. n.	21
Subfamily Holcorhynchellinae Dagys, 1974	
Piarorhynchella kittli sp. n.	13
Family **Cyclothyrididae** Makridin, 1956	
Costirhynchopsis sp. A	1
Costirhynchopsis sp. B	1
Costirhynchopsis sp. C	2
Order **SPIRIFERINIDA** Ivanova, 1972	
Family **Punctospirellidae** Dagys, 1974	
Punctospirella sp. ind.	1
?Dinarispira sp. ind.	4
Family **Mentzeliidae** Dagys, 1974	
Koeveskallina sp. A	8
Koeveskallina sp. B	2
Ptychomentzelia dobrogeana sp. n.	63
Ptychomentzelia simionescui sp. n.	10
Order **TEREBRATULIDA** Waagen, 1883	
Family **Dielasmatidae** Schuchert, 1913	
Adygella sp. ind.	2
Sulcatinella aff. *incrassata* (Bittner, 1890)	43
Family **Angustothyrididae** Dagys, 1972	
Rhaetina sp. ind.	2

Tab. 1 - List of late Spathian, Aegean and Bithynian brachiopods from North Dobrogea (Romania) described in the present paper, and number of specimens.

Brachiopod species	Sarica	Tulcea Veche	Desli Caira	Mandra	Orta Bair	Agighiol	Mahmudia
Grădinaru & Gaetani, this paper							
Norella kellneri (Bittner)			Sp2-Ae		Bi	Bi	
Austriellula iordanae sp. n.			Sp2-Ae		Bi		
Ortarhynchia petersi gen. n. sp. n.			Sp2-Ae		Bi	Bi	
Piarorhynchella kittli sp. n.							Bi
Costirhynchopsis sp. A			Ae				
Costirhynchopsis sp. B							Bi
Costirhynchopsis sp. C							Bi
Punctospirella sp. ind.							Bi
? Dinarispira sp. ind.							Bi
Koeveskallina sp. A							Bi
Koeveskallina sp. B							Bi
Ptychomentzelia dobrogeana sp. n.							Bi
Ptychomentzelia simionescui sp. n.							Bi
Adygella sp. ind.							Bi
Sulcatinella aff *incrassata* (Bittner)							Bi
Rhaetina sp. ind.							Bi
Kittl 1908, non-revised							
Spirigera marmorea var. *auriculata* Bittner			Sp2-Ae				
Rhynchonella cf. *arcula* Bittner			Sp2-Ae				
Rh. refractifrons cf. var. *bosniaca* Bittner			Sp2-Ae				
Spirigera aff. *balatonica* Bittner			Sp2-Ae				
Simionescu 1910a, non-revised							
Rhynchonella (Norella) kellneri Bittner				Sp2-Ae			
Spirigera marmorea var. *auriculata* Bittner				Sp2-Ae			
Rhynchonella aff. *nux* Suess				Sp2-Ae			
Rhynchonella sp.				Sp2-Ae			
Simionescu 1911, non-revised							
Spiriferina sp.		Sp1					
Rhynchonella sp.		Sp1					
Mirăuță et al. 1984, non-revised **Iordan 1993**, non-revised							
Spirigerellina pygmea Dagys	Sp1						
Fletcherithyris margaritovi (Bittner)	Sp1						
Crurithyris extima Grant	Sp1						
Hustedtiella cf. *planicosta* Dagys	Sp1						

Tab. 2 - Synopsis of Spathian, Aegean and Bithynian brachiopods from North Dobrogea, described in the present paper and mentioned in literature, showing their stratigraphic levels and localities of occurrence. *Abbreviations*: Sp1 – lower Spathian; Sp2 – upper Spathian; Ae – Aegean; Bi – Bithynian.

and *Caucasothyris* Dagys, 1974 also do not have the median plica in the sulcus in the dorsal valve.

Occurrence. The Mahmudia quarry, *Tubiphytes*-boundstone, layer 114, Bithynian.

The North Dobrogea brachiopod fauna (M. Gaetani)

The upper Spathian to Bithynian new brachiopod fauna of North Dobrogea is rather diversified, with three species in the upper Spathian (to which should be added one by Simionescu (1910a) and four by Iordan (1993), three in the Aegean and 15 species in the Bithynian (Tabs 1 and 2). The number of available specimens is, however, too low. Only seven species may be conveniently described, the others are represented by one or a few specimens in the collection.

They originate from two distinct environments, the pelagic limestone in the Hallstatt facies, and the *Tubiphytes* facies.

The pelagic limestones of the Hallstatt facies were sampled along the section of Deşli Caira, candidate as GSSP for the base of Anisian, and in the localities of Agighiol and Orta Bair, where the brachiopod assemblage is preserved in a fine reddish wackestone. Commonly, the brachiopods are

too rare and of small-size in the Hallstatt-type limestone of North Dobrogea (65 specimens), and they are represented only by species of Rhynchonellida, almost exclusively belonging to Norellidae, 98, 5% (Fig. 17). These species cross the Spathian /Anisian boundary, doubling their size in the Bithynian. The "Lilliput" effect in the Lower Triassic brachiopod fauna is already known (Chen et al. 2005; Zakharov & Popov 2014). A rather deep, quiet-water bottom may be suggested. It could be that the Rhynchonellida dominance is related to a nutrient poor environment in deep-water settings.

Simionescu (1910a), Mirăuță et al. (1984) and Iordan (1993) reported also species of Athyridida and Terebratulida. Unfortunately, the Iordan material is apparently lost, whereas of the material of Simionescu, only a few specimens of *Norella kellneri* and *Triadispira? marmorea auriculata* Bittner are preserved in the Museum of Palaeontological Collections in the University of Iași.The *Tubiphytes*-boundstone was sampled in the Mahmudia quarry (Popa et al. 2014). The main constituent of the boundstone are ramose individuals of the problematic organism *Tubiphytes*, a common fossil of the Anisian reef assemblages. Also important are local concentrations of ostracods, foraminifera, bivalves, brachiopods and crinoids, all embedded in large amounts of isopachous, fibrous, cm-thick cements (Popa et al. 2014). The Mahmudia brachiopod assemblage consists of about 151 specimens (plus about 30 fragmentary specimens not identified), extracted from a hard bioclastic whitish limestone. Apparently, this fauna is made of epifaunal suspension feeders, mostly pedicle-attached species. The assemblage is dominated by two species: *Ptychomentzelia dobrogeana* sp. n. and *Sulcatinella* aff. *S. incrassata* (Bittner, 1890), forming about the 70% of the assemblage. Mentzeliids, with *Ptychomentzelia* and *Koeveskallina* species representing 55.0 % of the assemblage (Fig. 17), are medium sized, while all the other species are small sized. Almost all are smooth or feebly costate forms. Only one specimen of *Punctospirella* sp. ind. has stronger costae. The two species of Rhynchonellida (*Costirhynchopsis* spp. B, C), representing only 2.0 % of the assemblage, have thin and sharp costae. Although smooth forms suggest deep or cool water, Vörös (2005) showed that in the Jurassic of Bakony, in Hungary, for which the paleolatitude was around 15-30° N, 94% of the brachiopod specimens are smooth forms, and argued this is not however indicative for a deep environment.

The same situation occurs in North Dobrogea, where the brachiopods are associated to and dwelling on the *Tubyphites* crusts. These microproblematica are thought to be light dependent organisms. The paleolatitude of North Dobrogea was around 30-35° N (pers. com. G. Muttoni 2017, on data by Gallet and Krystyn, in Grădinaru et al. 2007) during the Anisian. Vörös (2010) also noted that scaling ornamentation increases in size and importance during the Triassic, suggesting a relationship with the predation pressure. Was the Bithynian a time of low predation pressure?

The *Tubiphytes* facies has a highly abundant benthic macrofauna (gastropods, bivalves, brachiopods), as well as ostracods that should have lived in a high nutrient environment. The more diversified brachiopod fauna and the abundance of spiriferinids could suggest the presence of a more efficient filtering device as was hypothesized for the spiriferid/athyrids vs productids in the Pennsylvanian shallowing cycles (Pérez-Huerta & Sheldon 2006). Could it be the same for spiriferinids vs rhynchonellids in the Bithynian of North Dobrogea?

The recovery of Rhynchonellata brachiopods along the northern shores of the Palaeo-Tethys

The aftermath of the P/T crisis has been discussed by many authors during the last tens of years (e.g. Erwin et al. 2002; Chen et al. 2005; Zakharov & Popov 2014; Chen et al. 2015; Ke et al. 2016). It is now widely accepted that after a short time of survival of Permian taxa during the early Griesbachian, the early recovery started in the late Griesbachian, followed by a long interval of recovery and dispersal between the Dienerian and Olenekian, to eventually reach the final radiation during the Anisian (Chen et al. 2005; Bottjer et al. 2008; Chen & Benton 2012).

In the Lower Triassic, Rhynchonellida were the best represented, mostly by the superfamily Norelloidea. According to Chen et al. (2005), Rhynchonellida formed 46,8 % of the total taxa, Terebratulida 25%, Athyridida 18,7%, and Spiriferinida 9,5%.

The additional data published in the following years did not significantly change this general picture (Zakharov & Popov 2014; Chen et al. 2015). The distribution of biotic provinces was analysed

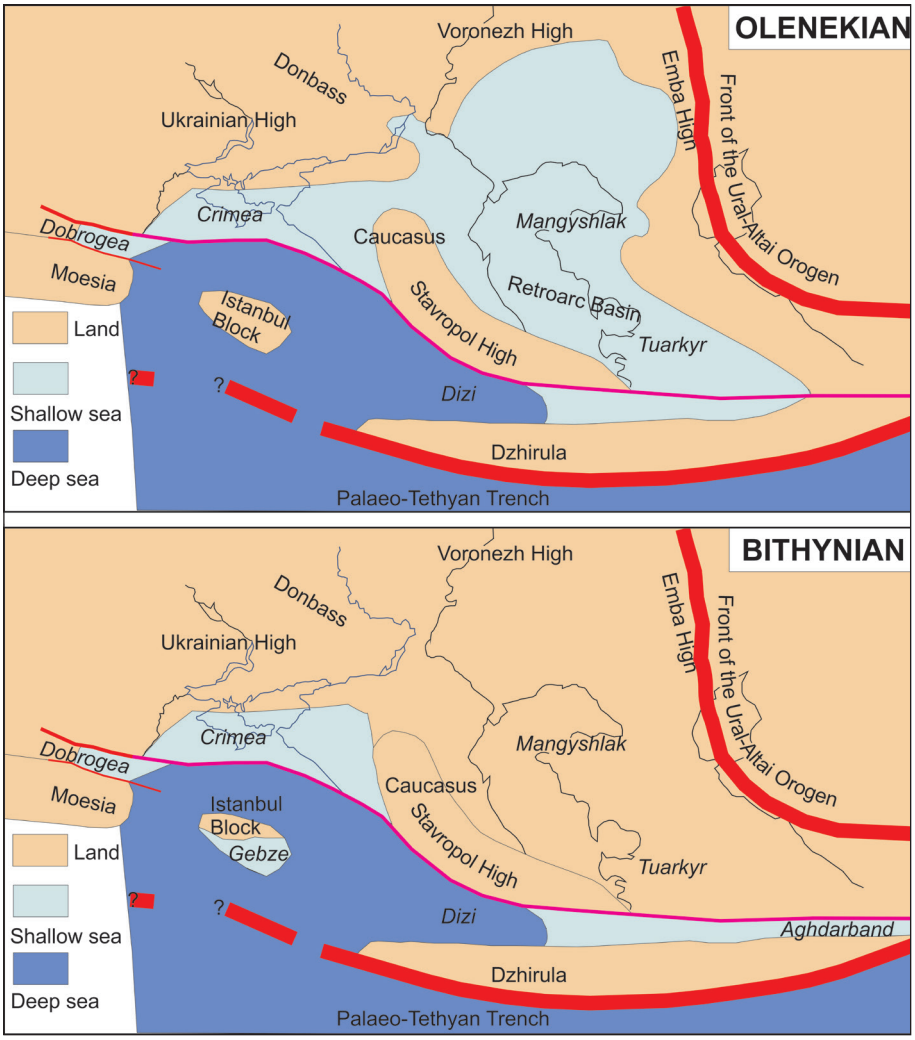

Fig. 16 - Palaeogeographic map of the northern shores of the western Palaeo-Tethys during the Olenekian and early Anisian. Redrawn and simplified from Gaetani et al. (2000) and Garzanti & Gaetani (2002).

by Ke et al. (2016).

The main radiation occurred in the Anisian. According to Hallam & Wignall (1997) and Sepkoski (2002), about 50 genera of Rhynchonelliformean brachiopods occur during the Anisian. However, this datum includes the whole Anisian. In fact, the true blossoming occurred in the Pelsonian, at least in the western Palaeo-Tethys (Gaetani, pers. data). The Bithynian taxa were not yet so abundant.

The subsequent geological evolution and collision/orogenies along the northern shores of the Palaeo-Tethys, mostly affected the Lower and Middle Triassic records in Central Asia and caused the present occurrence in two separate areas: the China blocks at the east (Cathaysian Province) and the belt from Kazakhstan to the Alps at the west (Western Tethyan Province). Together they may be grouped in the Tethyan Realm (Ke et al. 2016). However, it should be noted that the analyses and percentages on which these two areas are defined are based on lists of taxa, without having a taxonomic evaluation of the validity of all of these taxa. Nor was the number of specimens represented by each species calculated.

In the Bithynian of North Dobrogea, Terebratulida are represented by only three species, being 31.1 % of the assemblage (Fig. 17). However, one of them, *Sulcatinella* aff. *S. incrassata*, is the most abundant, being 28.4 %. Terebratulida seems to be less represented in comparisons to the Spiriferidina or Rhynchonellida, which form together more than half of the population, 68.9 % (Fig. 17).

Cathaysian Province. The recovery of Rhynchonelliformean brachiopods after the P/T crisis is up to now better documented on the eastern arms of the Palaeo-Tethys (Komatsu 2004; Chen et al. 2005; Chen et al. 2010a,b; Ke et al. 2016).

Along the shores of the South China block, assemblages with a fully Mesozoic aspect are developing from the late Griesbachian (Chen et al. 2015). They are rare during the earliest Triassic, represented mainly by lingulids. In the Spathian (Olenekian)

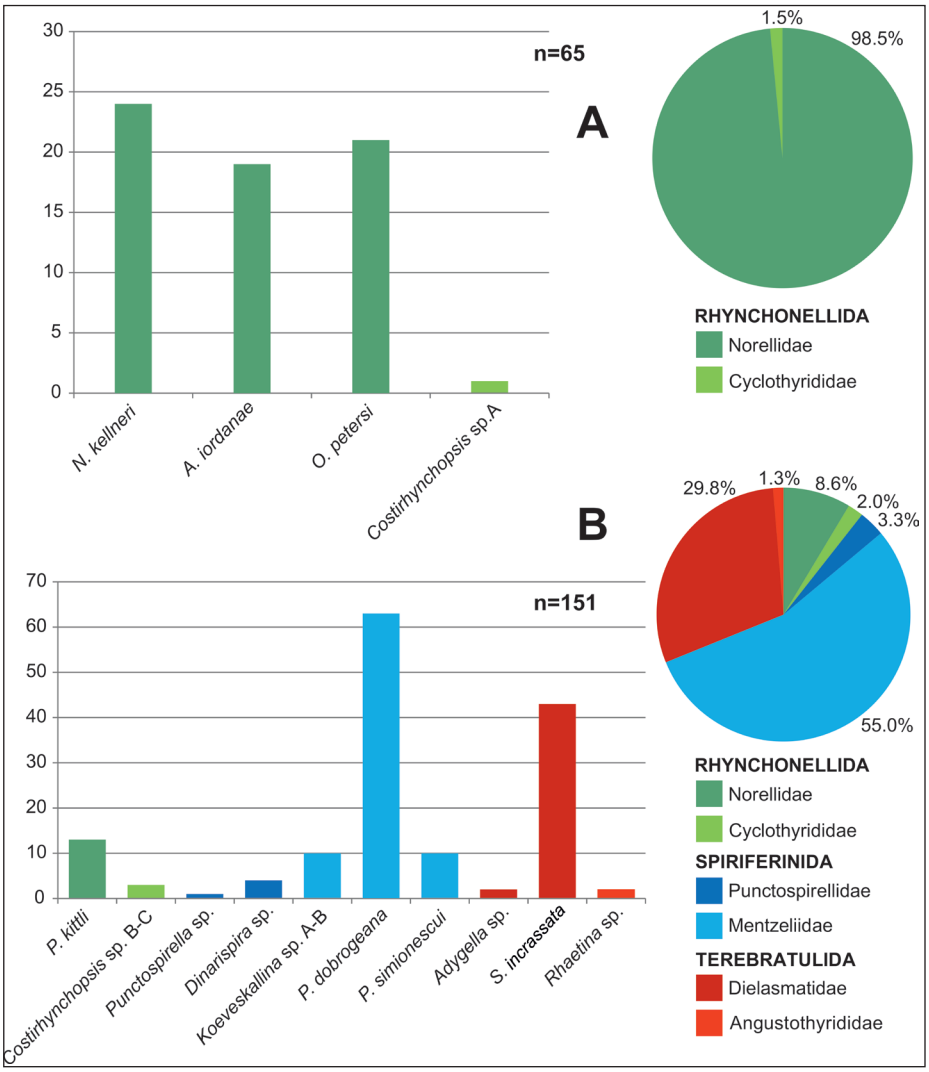

Fig. 17 - Histograms showing the relative abundance of the studied brachiopod species and pie-charts illustrating the family diversity of the upper Spathian to Bithynian brachiopods in the Hallstatt facies from Deşli Caira, Agighiol and Orta Bair (A) and in the Bithynian *Tubiphytes*-microbial facies at the Mahmudia quarry (B).

six species of Rhynchoneliformean brachiopods are known. In the Olenekian of South China, Rhynchonellida formed 33%, Spiriferinida 45%, and Athyridida 22% (Chen et al. 2015). Instead, brachiopod assemblages became definitely richer in the Aegean (25 species) and Bithynian (26 species) substages of the Anisian (Chen et al. 2010a,b; Ke et al. 2016). Athyridida, Rhynchonellida, Spiriferinida, and Terebratulida are present, and all are characterized by relatively small size, a biconvex shell, weak ornamentation and pediculate shells (Ke et al. 2016). In the Pelsonian, a slightly lower number of species has been reported.

As regards the diversity, in the Aegean, Rhynchonellida formed 20%, Spiriferidina 44%, Athyridida 16 %, and Terebratulida 20% (Chen et al. 2015). In the Bithynian, Rhynchonelliformea are represented by 26 species, most of them already present in the Aegean. Only four new entries are reported, while three are missing in the Bithynian. The percentage does not change significantly, with Rhynchonellida at 27%, Spiriferidina at 46%, Athyridida at 15 %, and Terebratulida at 12 %. In the Bithynian, Spiriferidina and Rhynchonellida prevail, at least with regard to number of species. To be noted is the importance of the mentzeliids also in China (He et al. 2015).

Western Tethyan Province. The Induan stage of the Lower Triassic has no suitable facies for preservation of Rhynchonelliformean brachiopods. Only some lingulids are known (Posenato et al. 2014). In the Olenekian, particularly in the Spathian, data are more consistent: Mangyshlak in Kazakhstan, and North Dobrogea (present study). Of interest are the findings in the Dolnapa area (Mangyshlak hillocks, Kazakhstan). Dagys (1974) reported four species from the Olenekian: *Piarorhynchella mangyshlakensis* Dagys, *Costispiriferina mansfieldi* Girty, *Spirigerellina pygmaea* Dagys, and *Fletcherithyris margaritovi* Bittner (now *Bittnerithyris* in Popov

& Zakharov 2017*)*. In addition to the species quoted by Dagys (1974), Zakharov & Popov (2014) mention the occurrence of *Hustedtiella planicosta* Dagys, *Spirigerellina* sp., *Antezeilleria* sp., *Proanadyrella* (?) sp., and new species of *Prelissorhynchia* (?), *Lissorhynchia*, and *Thyratryaria*. Several species are represented by small sized specimens, considered under the "Lilliput effect". It should be noted that the Mangyshlak Gulf was partially closed during the Olenekian, and the ammonoid fauna is largely endemic (Balini et al. 2000) (Fig. 16). Some of these species are also present in Primorye in eastern Russia (Zakharov & Popov 2014; Popov & Zakharov 2017; Popov, pers. comm. 2017). The marine succession in Mangyshlak ends with the Olenekian and the overlying Anisian is in clastic facies (Gaetani et al. 1998; Balini et al. 2000; Zakharov & Popov 2014). In Mangyshlak, Rhynchonellida form 27.2%, Spiriferinida 9%, Athyridida 27.2%, and Terebratulida 36.3%.

Kittl (1908), Mirăuţă et al. (1984) and Iordan (1993) quoted four species in the Spathian from different localities of North Dobrogea, *Spirigerellina pygmaea* Dagys, *Fletcherithyris* (now *Bittnerithyris*) *margaritovi* (Bittner), and *Hustedtiella* cf. *planicosta* Dagys. The identification of *Crurithyris extima* Grant is doubtful because it is a Permian species. These specimens originate from the "platy limestone formation" cropping out east of Sarica, in the northeast area of the Niculiţel Unit, in reddish partly dolomitized limestones associated with dark greyish limestones that are underlain by basalts (Mirăuţă et al. 1984). In our collection, three additional species are found: *Norella kellneri* Bittner, *Austriellula iordanae* sp. n. and *Ortarhynchia petersi* gen. n.sp. n., all coming from the Hallstatt-type limestones cropping out at Deşli Caira, Agighiol and Orta Bair, all located in the Tulcea Unit. Including Iordan's (1993) identifications, in North Dobrogea, Rhynchonellida form 42.8%, Athyridida 28.5%, and Terebratulida 28.5%.

In Bulgaria, Ganev (1961) reported the presence of *Terebratula* (now *Bittnerithyris*) *margaritovi* Bittner in the Olenekian of the Stara Planina. No Rhynchonelliformean brachiopods are known from the Alps, Dinarids and Transdanubian Range.

No brachiopod species have been so far reported from the Aegean substage, which is poorly documented in the Western Tethyan Province. Only in North Dobrogea and in Albania, the Aegean substage is documented by conodonts and ammonoids (Grădinaru et al. 2007; Germani 1997), besides the type-locality in Chios Island (Assereto 1974; Gaetani et al. 1992).

In the present study, four species are recorded in the Aegean of Deşli Caira in North Dobrogea, and are very rare, i.e. *Norella kellneri* Bittner, *Austriellula iordanae* sp. n., *Ortarhynchia petersi* gen. n.sp. n., and a single specimen of *Costirhynchopsis* sp. *A*.

Within the Bithynian, the scenario changes dramatically. The North Dobrogea assemblage here described is the richest, with 15 species, mainly belonging to Rhynchonellida, Spriferinida, and Terebratulida. Amongst Spiriferinida, metzeliids with 55.0 % largely prevail (Fig. 17).

Up to now, in the western Palaeo-Tethys only three localities with brachiopods are referred to the Bithynian substage, in which the age is confirmed by ammonoids: North Dobrogea in Romania, Gebze in Turkey, and Aghdarband in Iran.

The Gebze assemblage (Gaetani 2016) has a rather high density, with two rhynchonellids, *Austriellula kavakensis* (Arthaber), *Holcorhynchella edhemi* (Toula), one spiriferinid, *Ptychomentzelia propontica* (Toula), and a single specimen of *Angustothyris angustaeformis* (Böckh). The brachiopods are preserved in thin bedded, nodular marly limestones that alternate with marlstones, deposited under wave base in a muddier environment.

The Anisian succession of the Gebze area belongs to the Istanbul Terrane (Gaetani 2016; Lom et al. 2016). There is a current tectonic model according to which the Istanbul Terrane allegedly rifted off from the Romanian/Ukrainian conjugate margin that is arbitrarily labelled as the so-called "Odessa Shelf", and was translated southward opening the West Black Sea basin during the Cretaceous (e.g. Okay et al. 1994; Okay & Tüysüz 1999; Okay & Görür 2007; Tari et al. 2015; Tüysüz 2018; Okay et al. 2018). The Bithynian (Anisian, Middle Triassic) ammonoid and brachiopod faunas of the Istanbul Terrane (Fantini Sestini 1988; Gaetani 2016) have no counterparts in the Triassic successions of the geological units underlying the so-called "Odessa Shelf", i.e. the Scythian Platform, the North Dobrogean Orogen and the Moesian Platform. The Gebze Middle Triassic fauna, which inhabited the Istanbul Terrane located far southward of the shore of Laurasia, shows close affinities with the Middle Triassic fauna of Aghdarband in Iran (Krystyn & Tatzreiter 1991; Siblik 1991), which was located much farther eastwards on the northern shore of

Fig.18 - Group photo of the participants at the Workshop on the Lower-Middle Triassic (Olenekian-Anisian) boundary, 7-10 June 2000, Tulcea, Romania. Back row, from left - Jerzy Nawrocki, Andrzej Gazdzicki, Alda Nicora, Milan Sudar, Elizabeth Carter, Ioan Coconu, Maurizio Gaetani, Mike Orchard, Miloš Siblik, Vladlen Lozovsky, Mikhail Shishkin, Eugen Grădinaru, Aleksandr Shevyrev, Iuliana Lazăr, Mihai Popa; front row, from left - Tea Kolar-Jurkovšek, Kinga Hips, Daria Ivanova, Lyudmila Petrunova. In the background, the southern slope of the Deşli Caira hill exposes the upper Spathian-lower Anisian (Aegean) section that is the leading GSSP candidate for the base of the Anisian.

the Palaeo-Tethys (Fig. 16). Therefore, from the viewpoint of Middle Triassic palaeogeography, the Istanbul Terrane cannot be conceived in any case as representing the conjugate Turkish margin of the so-called Romanian/Ukrainian "Odessa Shelf". On the other hand, the true Odessa Shelf is underlain solely by the East European Platform, at the north, and the Scythian Platform, at the south (see fig.1 in Hippolyte et al. 2018).

The assemblage of Aghdarband (Siblik 1991) consists of *Costirhynchia* (now *Costirhynchopsis*) *ruttneri* Siblík, *Punctospirella* aff. *P. fragilis* (Schlotheim), *Dareithyris vulgaris* Siblík, and a stratigraphically doubtful occurrence of *Tetractinella trigonella* (Schlotheim). The rhynchonellid *Costirhynchia ruttneri* is the most abundant, while the other species are represented by a single or a few specimens. Brachiopods originate from the upper part of the Nazar-Kardeh Formation, consisting of greenish-grey nodular and partly siliceous limestone beds alternating with shales and sandstones (Krystyn & Tatzreiter 1991; Zanchi et al. 2016). Apparently, the bottom conditions at Aghdarband were less turbid than in Gebze.

The Bithynian brachiopod fauna from the northern shores of the western Palaeo-Tethys (not less than 22 species) consists of Rhynchonellida (40.9%), Spiriferinida (36.3%), and Terebratulida (22.7%). No Athyridida are known.

It does not differ in number of species from the South China fauna (26 species, Chen et al. 2015). A significant difference is, however, the composition of the assemblages. In South China, Rhynchonellida forms 27%, Spiriferidina 46%, Athyridida 15 %, and Terebratulida 12 %. However, the Mentzelioidea are subordinate within the Spiriferinida, while in the western Palaeo-Tethys the Mentzelioidea are prevailing within the order. All the Rhynchonellata orders surviving the P/T crisis are represented. The faunal assemblages differ significantly at the various localities, with very few species shared by at least two localities. This fact is largely dependent on the different environmental conditions.

During the Pelsonian, brachiopods continued to radiate after the P/T crisis, especially on the western shores of the Palaeo-Tethys. The major occurrences are along the shelves of the Adria promontory (Southern Alps in Italy, Balaton area in Hungary, Dinarids, Balkans (Bittner 1890, 1903; Martelli 1906; Diener 1920; Metzeltin 1973; Pálfy 1990; Benatov 2001, amongst others), reaching a total number of about 50 species.

Contrary to the South China, where the num-

ber of Pelsonian species equals the Bithynian number, in the western Palaeo-Tethys the Pelsonian brachiopods show a real blossoming. The favourable environmental conditions allowed this blossoming, as it may be observed in other benthic groups like Foraminifera, who had a maximum in their development in the Pelsonian (Rettori 1995, Rettori et al. 1994).

The knowledge of the brachiopod fauna, from Early Triassic to the early Anisian, appears to still be largely incomplete and spotty. The reported percentages are very rough, because they do not consider the type of environment and the number of specimens within the species. The occurrences are also linked to the environmental conditions that control the existence and preservation of the fauna itself. However, notwithstanding this bias, the recovery of brachiopods, especially from the early Anisian onward, has been largely secured.

Conclusions

The brachiopod fauna from the late Spathian to the Bithynian of North Dobrogea casts a new light on the recovery of the brachiopods after the P/T crisis. Seven species belonging to three families are known from the Spathian. The Aegean documentation is poor, but in fact is the only one controlled by ammonoid/conodont biostratigraphy, as compared with other localities worldwide. The Bithynian fauna of North Dobrogea is instead proportionally rich, demonstrating that the brachiopod fauna was already largely diversified. It is rarely documented worldwide, because of the absence of preserved suitable environments. The paucity and the random records of brachiopods are thus more due to preservational conditions, than to a delay in the recovery of faunal diversity after the P/T crisis.

Acknowledgements: EG is highly indebted to the Staff of the Mahmudia quarry SC-MIN-EST SA for unlimited access and support during many decades in the study of Triassic limestones and collecting fossils, through the persons of Director-General Eng. Lorin Poiană and Eng. Geol. Adrian Tertiș. MG thanks Alexander Popov and Yuri Zakharov (Vladivostok) for papers and pre-prints of their current studies. Daria Ivanova (Sofia) is thanked for tracing of the Ganev material from Stara Planina. Marian Constantin and Ștefan Vasile (Bucharest), who assisted in computer drawing of some illustrations, are warmly thanked. Attila Vörös (Budapest) and Lucia Angiolini (Milano) are gratefully acknowledged for the constructive reviews of the manuscript. Spencer Lucas (Albuquerque) is kindly thanked for polishing the English style. EG acknowledges with appreciation the RIPS technical editor Cristina Lombardo. The field works done by EG in North Dobrogea were financially supported by the Romanian Academy through grants 84/1999 and 368/2001-2002, and by the UEFISCDI (Ministry of National Education) through grant PNCDI-II-ID-1960/2009-2010, respectively.

In Homage to Maurizio Gaetani (1940-2017): Brachiopods were for Maurizio Gaetani his first love in Palaeontology. In the last three years he was very active on the Triassic brachiopods by publishing several papers (Gaetani & Mantovani 2015; Gaetani 2016; Gaetani et al. 2018). The project devoted to the study of the upper Spathian to Bithynian brachiopods from North Dobrogea started in mid January 2017 when Maurizio came to Bucharest, in spite of a harsh winter, to take the material. Maurizio worked frantically, so the first results of the taxonomic study could be presented by him at the 11th Romanian Symposium on Palaeontology, Bucharest, 27-28 September 2017 (Grădinaru & Gaetani 2017). Before his unexpected passing, Maurizio finalized the chapter on the Systematic Palaeontology and the next two chapters of the manuscript. In our last emails changed at the end of November 2017, Maurizio proposed to publish the paper in Rivista Italiana di Paleontologia e Stratigrafia. Surely, he never believed that the present paper would be published in the Homagial Volume dedicated to his life and professional career. As a co-author of the present paper, I am very grateful to Maurizio, who in the last year of his life focused on the study of the late Spathian to Bithynian brachiopods of North Dobrogea, which otherwise would remained unstudied in my drawers. Over the years, I guided Maurizio in several field trips in North Dobrogea to show him the most important sections of the Triassic, and I remember his high devotion and also his great delight to look on other scenaries of the Triassic World. Last but not least, Maurizio enthusiastically attended the Workshop on the Lower-Middle Triassic (Olenekian-Anisian) boundary, 7-10 June 2000, Tulcea, Romania (Fig. 18), and he has been one of the most authorized advocates that supported the GSSP candidacy of the Deşli Caira section for the base of the Anisian.

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