

CAMPANIAN-MAASTRICHTIAN BENTHIC FORAMINIFERA FROM THE BYALA FORMATION (EASTERN BALKAN)

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ABSTRACT. The Byala Formation, developed in the tectonically complicated boundary region between the Eastern Fore Balkan and Eastern Balkan, is well investigated from paleontological and stratigraphical point of view. Despite this fact, the small foraminiferal content of the Campanian-Maastrichtian part of the unit have not been studied micropaleontologically in details. The present article is focused on the benthic foraminiferal assemblages, which are rich and diverse. The studied samples were picked up from three sections (Byala-south and Byala-north, revealing the uppermost Maastrichtian levels, and Beliya Nos-Byala River, comprising Lower Campanian to Maastrichtian levels) and several outcrops located on the seacoast around the town of Byala, Varna district. The studied assemblages are composed of both agglutinated and hyaline taxa with broad stratigraphical range. They are in varied proportions and show high taxonomic diversity (totally 84 species) and specimen' abundance. This fact provides a good opportunity for paleoecological interpretations. As a whole, the established benthic foraminiferal fauna could be referred to the widespread in the Tethian realm hemipelagic Velasco-type fauna.

Keywords: benthic foraminifers, Campanian, Maastrichtian, Byala Formation, Eastern Balkan

КАМПАН-МАСТРИХТСКИ БЕНТОСНИ ФОРАМИНИФЕРИ ОТ БЕЛЕНСКАТА СВИТА (ИЗТОЧНА СТАРА ПЛАНИНА)

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РЕЗЮМЕ. Беленската свита, развита в тектонски усложнения граничен район между Източния Предбалкан и Източния Балкан, е добре изучена в палеонтоложко и стратиграфско отношение. Независимо от този факт асоциациите от малки фораминифери от кампан-мастрихтската част на единицата не са били обект на детайлни микропалеонтоложки изследвания. Настоящата статия е фокусирана върху асоциациите от бентосни фораминифери, които са богати и разнообразни. Изследваните проби са събрани от три разреза (Бяла-юг, Бяла-север, представящи най-горните мастрихтски нива, и Белия нос-Бяла река, включващ долнокампанско-мастрихтски нива) и няколко единични разкрития, намиращи се на морския бряг в района на гр. Бяла, Варненска област. Изследваните асоциации са изградени от таксони с аглутинирана и хиалинна черупка с широко стратиграфско разпространение и във вариращи съотношения. Те показват високо таксономично разнообразие (общо 84 вида) и изобилие от екземпляри. Този факт предоставя добра възможност за палеоекологични интерпретации. Като цяло установената бентосна фораминиферна фауна може да бъде отнесена към широко разпространената в Тетиския регион фауна от типа Velasco, характерна за хемипелагичната зона.

Ключови думи: бентосни фораминифери, Кампан, Мастрихт, Беленска свита, Източна Стара планина

Introduction

The Campanian–Paleocene Byala Formation is developed in a small area in the Eastern Balkanides and it is well investigated from paleontological (calcareous nannofossils, ammonites, echinoids, inoceramids, and partly small foraminifers) and stratigraphical (lithostratigraphy, biostratigraphy, chronostratigraphy, cyclic and event stratigraphy) point of view.

The first data on the rocks of the Byala Formation were published by Златарски (1907), who described them as "whitish limy marls". Later on Бончев (1926) named the rocks "Byala clayey marls". Джуранов, at first (Джуранов, 1984) united them into "limestone-marl formation", and then (Джуранов, 1991) formalized the unit as "Byala limestone-marl Formation" (see also Джуранов, 1993). Initially the rocks were referred to the Northeuroean type Upper Cretaceous (Гочев, 1932; Коен, 1938; Ботев, 1953), but since the beginning of the

1960s they have been considered to belong to the Mediterranean type (Трифенова, 1960a; Атанасов, 1961; Синьовски, 2007; Дабовски et al., 2009). Detailed reviews on the geological investigations on the unit were given by Синьовски (2006) and Дабовски et al. (2009).

It should be noted that, despite the initial foraminiferal studies (Трифенова, 1960a, b), the detailed investigations on small foraminifers (biostratigraphical zonations – Juranov, 1983; Valchev, 2003a; paleoecological interpretations – Valchev, 2003b, 2004; taxonomical study – Вълчев, 2001) were focused predominantly on the Paleocene part of the Byala Formation. First planktonic foraminiferal data concerning the lowermost (Campanian) levels of the formation were recently published (Valchev, 2017). Therefore, the present article aims (i) to reveal the taxonomical composition and structure of the benthic foraminiferal assemblages from the Campanian–Maastrichtian levels of the Byala Formation, (ii) to elucidate the stratigraphical

range of the taxa and (iii) to estimate their paleoecological significance.

The Byala area is of great interest because here the Cretaceous/Tertiary boundary was first established in Bulgaria (Stoykova, Ivanov, 1992) in the frame of Bulgarian–Austrian project led by Prof. Anton Preisinger. Later on, the outcrops north of Byala beach were announced as protected geosite named “Belite Skali” (Синьовски, 2003) which is included in the “Register and Cadastre of the Geological Heritage of Bulgaria” (Синьовски in Желев, Синьовски, 2003¹).

Geological Setting

The area of study is part of the Eastern Balkanides and it comprises the tectonically complicated boundary region between the Eastern Fore Balkan and Eastern Balkan (Fig. 1). It is characterized by the presence of numerous normal, reverse and thrust faults at a various scale (Fig. 2 shows the largest ones only). The biostratigraphical investigations conducted previously (e. g. Juranov, 1983; Джуранов, 1989, Синьовски, 2006) proved that there is no complete section of the Byala Formation revealing its total stratigraphical range. Moreover, it was established that there are cases of overturned stratigraphical successions or repeatedly occurring stratigraphical levels (Джуранов, 1989).

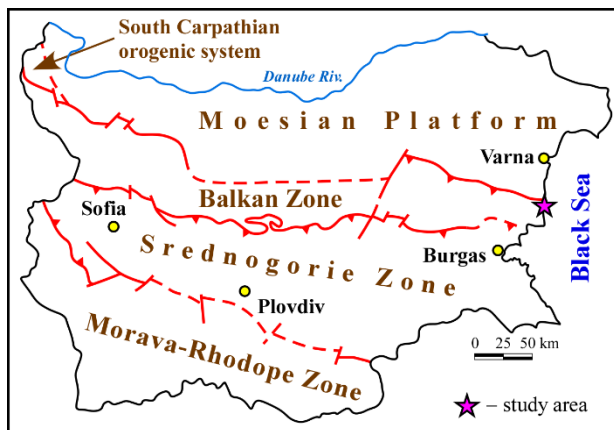


Fig. 1. Tectonic subdivision of Bulgaria (after Дабовски and Загорчев, 2009) with the location of the area of study

As a whole, the Byala Formation comprises rhythmic limestone-marl successions related to climatic oscillations (Preisinger et al., 1993a, b) which alternate with monotonous marl intervals. Sinnyovsky (2001) described the rhythmic intervals as “typical periodite alternation” resulting from high frequency climatic cycles of Milankovich and proved, on the basis of sedimentological analyses on samples from the Upper Maastrichtian–Danian interval, that the “marl” beds in fact are limestones. Thus, these alternations could be considered as cyclic limestones. The periodites are typical predominantly for the Campanian and Danian parts of the Byala Formation. They

consist of couples of prominent limestone beds and soft back-weathering interbeds (Plate 1a, b) with periodicities of about 1 m (Sinnyovsky, 2001; Синьовски, 2006).

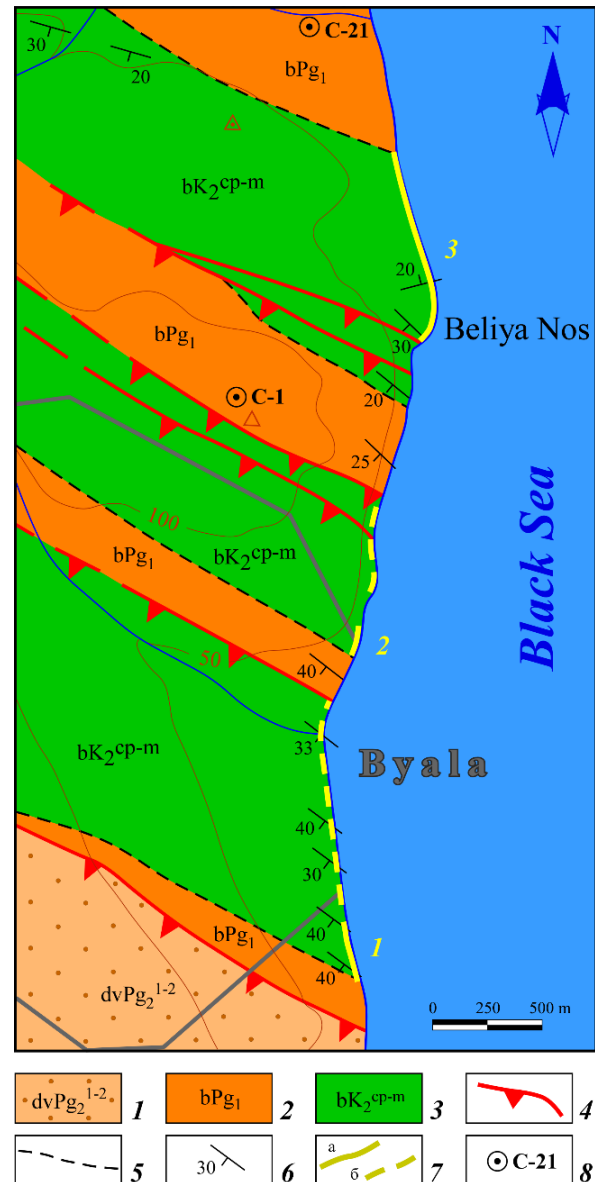


Fig. 2. Geological map of the coastal part of the Byala area (after Джуранов et al., 1994²)

1, Dvoynitsa Fm.: medium to coarse-grained thick-bedded sandstones, alternating with thin-bedded fine-grained sandstones, siltstones, marls and conglomerates (Lower–Middle Eocene); 2–3, Byala Fm.: alternation of clayey limestones and marls (2, Paleocene, 3, Campanian–Maastrichtian); 4, thrust; 5, chronostratigraphic boundary; 6, bedding; 7, section (a) and outcrop (b): 1, Byala-south, 2, Byala-north, 3, Beliya Nos–Byala Reka; 8, borehole

The studied samples were picked up from three outcrop sections located on the sea coast in the surroundings of the town of Byala (Figs. 2, 3). Two of them (Byala-south, exposed

¹ Желев, В., Д. Синьовски (ред.). Регистър и кадастър на геоложките феномени в България. 188 досиета в 5 тома. Национален геофонд, доклад XV-1232, 2003. (Jeleв, V., D. Sinnyovsky (Eds.). Registar i kadastar na geolozhkite fenomeny v Balgariya. 188 dosieta v 5 toma. Natsionalen geofond, doklad XV-1232, 2003.)

² Джуранов, С., Д. Синьовски, Д. Вангелов, Х. Пимпирев, М. Антонов, В. Желев, Г. Балтаков, И. Чолеев. Доклад за резултатите от изпълнението на геоложка задача: “Геоложка и геоморфоложка картиране в М 1:25 000 на част от Източния Балкан между нос Емине и с. Старо Оряхово на площ 330 кв. км.”. Нац. геофонд, доклад IV-411, 1994. – 408 с. (Juranov, S., D. Sinnyovsky, D. Vangelov, H. Pimpirev, M. Antonov, V. Jeleв, G. Baltakov, I. Choleev. Doklad za rezultatite ot izpalnenieto na geolozhka zadacha: “Geolozhko i geomorfolozhko kartirane v M 1:25 000 na chast ot Iztocniya Balkan mezhdu nos Emine i selo Staro Oryahovo na ploshht 330 kv. km.”. Natsionalen geofond, doklad IV-411, 1994. – 408 p.)

at the beach, and Byala-north, located north of the beach) reveal the uppermost Maastrichtian levels (Plate 1c, d). The third one crops out between Beliya Nos Cape and Byala River mouth north of the town of Byala, and it comprises Lower

Campanian to Upper Maastrichtian levels (Plate 1e, f). Some small scale faults, but without data for visible displacement, are observed in the lower half of this section (Plate 1g).

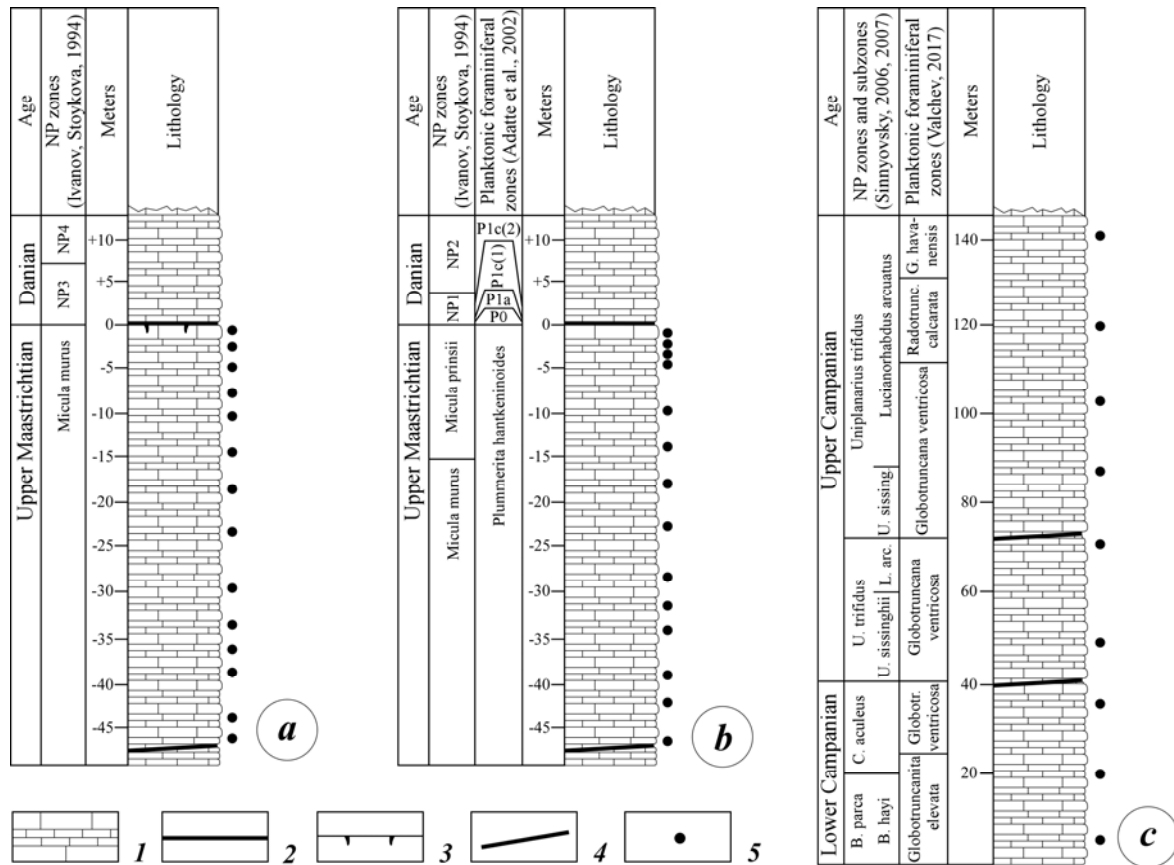


Fig. 3. Stratigraphical columns of the sections Byala-south (a), Byala-north (b) and Beliya Nos Cape (c)
1, cyclic limestones; 2, K/T boundary clay layer; 3, hard ground; 4, fault

Samples from several outcrops located on the Byala beach as well as between Byala-north section and Beliya Nos Cape were studied for deriving additional taxonomical data. Here, the tectonic structure is quite complicated – the rocks are displaced by a series of faults and folded (Plate 1h).

Benthic foraminiferal assemblages

Taxonomical diversity and specimen abundance

The studied samples revealed high taxonomical diversity of the benthic foraminiferal assemblages – totally 84 species were recorded (see Appendix). The Lower Campanian levels demonstrate lowest diversity – 26 species established. The assemblages are dominated by taxa with hyaline tests such as *Gavelinella beccariiiformis* (White), *Nuttalides trümpyi* (Nuttal), *Nuttalides* sp., *Lenticulina velascoensis* White, accompanied by the species with agglutinated tests *Ammodiscus cretaceus* (Reuss), *A. glabratus* Cushman and Jarvis, and *Marssonella oxycona* (Reuss). All of them occur as rare specimens. The secondary contributors, including some representatives of nodosariids, heterolepids, bolivinoids, are represented sporadically by single specimens.

The Upper Campanian samples contain more diverse assemblages – up to 40 species were recorded. Here the dominating taxa are the same as in the Lower Campanian, but with increased occurrence of the species with agglutinated tests *Clavulinoides amorphous* (Cushman) and *C. trilaterus* (Cushman) in addition. Here, *Gaudryina cretacea* (Karrer), *G. pyramidata* Cushman, and *Quadriformina allomorphinoides* (Reuss) are present as rare specimens. The secondary contributors, occurring as single specimens, are the same as in the Lower Campanian.

The Lower Maastrichtian assemblages include up to 60 species. “New” elements of the dominating group, amongst the above mentioned, are *Aragonia velascoensis* (Cushman), which is represented by rare to common specimens, and *Nodosaria longiscata* d’Orbigny occurring as rare specimens. *Gaudryina pyramidata* Cushman and *Oridorsalis megastomus* (Grzybovski) are also rarely encountered characteristic species. The presence of *Bulimina midwayensis* Cushman & Parker and *Guttulina ipatovcevi* Vassilenko amongst the secondary contributors should be noted.

The highest taxonomical diversity was recorded from the Upper Maastrichtian levels. All the 84 taxa were established in the samples from this part of the Byala Formation. The

dominating species here are *Nuttalides trümpyi* (Nuttal), *Gavelinella beccariiformis* (White), *Osangularia velascoensis* (Cushman), *Aragonia velascoensis* (Cushman), *Clavulinoides trilaterus* (Cushman), *Gaudryina cretacea* (Karrer), *G. pyramidata* Cushman, *Marssonella indentata* (Cushman and Jarvis), *Bathysiphon discreta* (Brady), *Neoflabellina jarvisi* (Cushman), *Gyroidinoides globosus* (Hagenow), *Bolivina midwayensis* Cushman. Minor elements in the assemblages are various nodosariids, lenticulinids, anomalinids, as well as taxa with agglutinated tests.

In this stratigraphical level a "new" element was recorded – the typical Late Cretaceous *Reussella szajnoche* (Grzybovski). It occurs rarely.

Biostratigraphical markers

All the species, recorded in this study, apart from *Reussella szajnoche*, are of broad stratigraphical range (Upper Cretaceous–Paleocene), therefore it is not possible to define biostratigraphical markers (FAD and LAD) on the base of benthic foraminifera.

Types of assemblages

The taxonomical composition and the structure of the benthic foraminiferal assemblages – dominating taxa such as *Gavelinella beccariiformis* (White), *Nuttalides trümpyi* (Nuttal), *Osangularia velascoensis* (Cushman), *Aragonia velascoensis* (Cushman), *Clavulinoides trilaterus* (Cushman), *Gaudryina cretacea* (Karrer), *G. pyramidata* Cushman, *Marssonella indentata* (Cushman and Jarvis), *M. oxycona* (Reuss) are typical for the Velasco-type fauna, characteristic for the hemipelagic realm and widely known from the Tethys region (Cushman, 1925, 1926; White, 1928a, b, 1929; Cushman, Jarvis, 1928; Braga et al., 1975; Proto Decima, Bolli, 1978; Tjalsma, Lohman, 1983; etc.).

Conclusion

The study of the Campanian–Maastrichtian benthic foraminiferal assemblages from the Byala Formation recovered from three sections and several outcrops on the sea coast in the surroundings of the town of Byala revealed that (i) they are of high taxonomical diversity, (ii) composed of taxa with broad stratigraphical range, and (iii) dominated by species, characteristic for hemipelagic conditions. The last fact gives a good opportunity for paleoecological reconstruction and further paleogeographical interpretation of the position of the Byala Formation in the Late Cretaceous–Early Paleogene geological structure of Eastern Bulgaria.

Appendix

Alphabetical list of benthic foraminiferal species

Allomorphina conica Cushman and Todd
Ammodiscus cretaceus (Reuss)
A. glabratus Cushman and Jarvis
A. peruvianus Berry
Anomalinoides sp.
Aragonia velascoensis (Cushman)
Astacolus gladius (Philippi)

Bannerella retusa (Cushman)
Bathysiphon discreta (Brady)
B. microrhaphidus Samuel
Bolivina midwayensis Cushman
Bolivinooides delicatulus Cushman
Bulimina midwayensis Cushman and Parker
Chilostomelloides sp.
Cibicidoides dayi (White)
Clavulinoides amorphous (Cushman)
C. trilaterus (Cushman)
Cyclammina sp.
Dendrophrya sp.
Dentalinoides fallax (Cushman and Dusenbery)
Ellipsoglandulina chilostoma (Rzehak)
Gaudryina cretacea (Karrer)
G. pyramidata Cushman
Gavelinella beccariiformis (White)
Globobulimina suteri (Cushman and Renz)
Guttulina ipatovcevi Vassilenko
Gyroidinoides globosus (Hagenow)
Haplophragmoides suborbicularis (Grzybovski)
H. walteri (Grzybovski)
Haplophragmoides sp.
Hormosina ovuloides (Grzybovski)
Hyperammina sp.
Kalamopsis grzybovskii (Dylazanka)
Karrerria fallax Rzehak
Karrerria sp.
Laevidentalina laticolis (Grzybovski)
Lenticulina velascoensis White
Lenticulina sp.
Marginulina sp.
Marssonella indentata (Cushman and Jarvis)
M. oxycona (Reuss)
Neoflabellina jarvisi (Cushman)
N. semireticulata (Cushman and Jarvis)
Nodosarella hedbergi Cushman and Renz
Nodosaria limbata d'Orbigny
N. longiscata d'Orbigny
Nodosaria sp.
Nonion sp.
Nuttalides trümpyi (Nuttal)
Nuttalides sp.
Oridorsalis megastomus (Grzybovski)
Osangularia velascoensis (Cushman)
Osangularia sp.
Paliolatella crebra (Mathes)
Paliolatella sp.
Pleurostomella kugleri Cushman and Renz
Praeglobobulimina sp.
Pseudoclavulina globulifera (ten Dam and Sigal)
Pseudonodosaria manifesta (Reuss)
Pseudonodosaria sp.
Pullenia coryelli White
P. quinqueloba (Reuss)
Pygmaeoseistrion laevis (Montagu)
P. oxystomum (Reuss)
Pyramidulina raphanus Linnè
P. velascoensis (Cushman)
Pyramidulinoides sp.
Quadrimorphina allomorphinoides (Reuss)
Q. cretacea (Reuss)

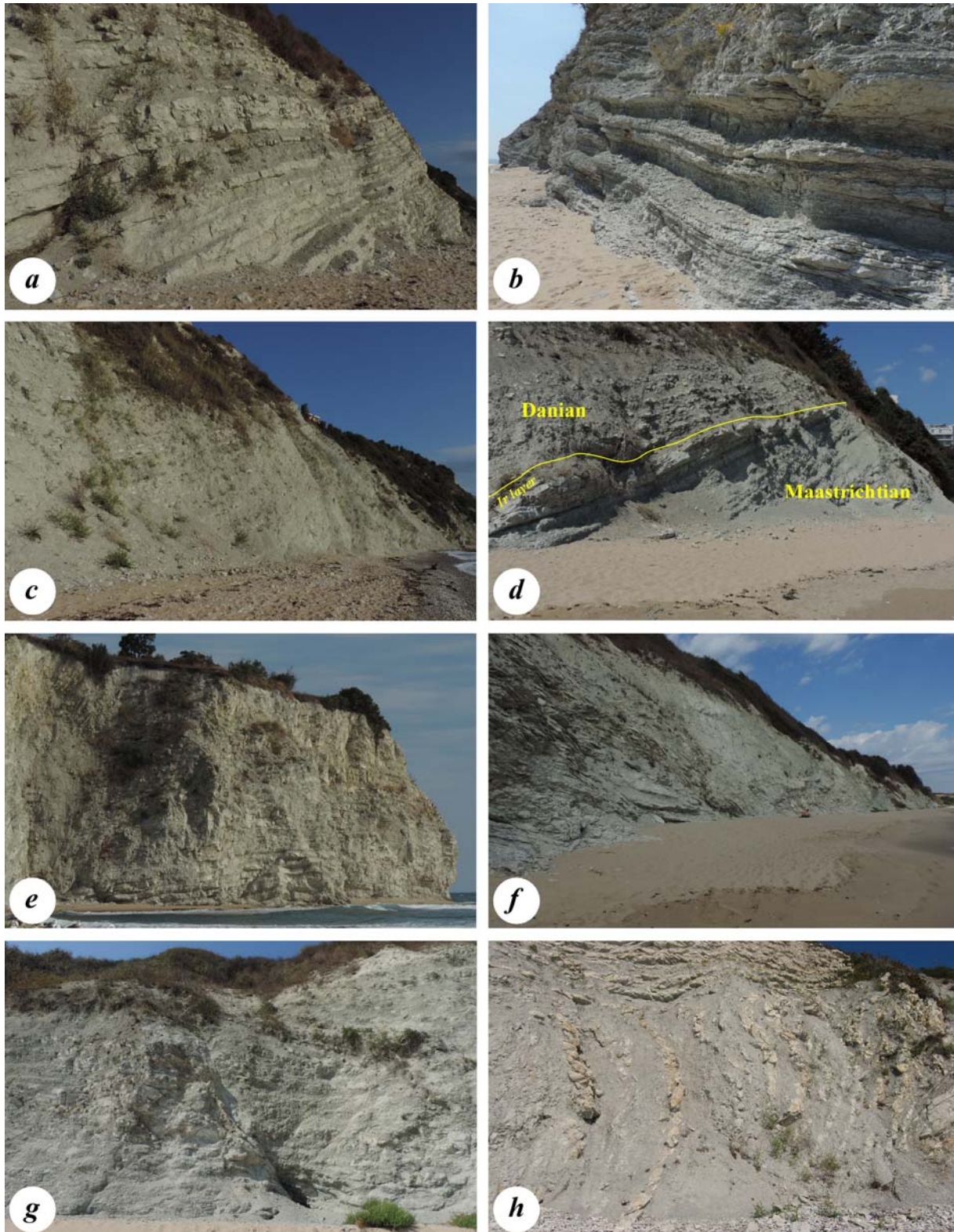
Rhizammina indivisa Brady
Recurvoides sp.
Repmanina charoides (Jones and Parker)
Reussella szajnoche (Grzybovski)
Reusoolina globosa (Montagu)
Reusoolina sp.
Saccamina complanata (Franke)
S. placenta (Grzybovski)
Saracenaria arcuata (d'Orbigny)
S. hantkeni (Cushman)
Textularia plummerae Lalicker
Trochamma sp.
Trochamminoides sp.
Vaginulinopsis longiformis (Plummer)
V. pedum (d'Orbigny)

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PLATE I



a) periodites in the upper part of Byala–north section (Upper Maastrichtian); b) cyclic limestones at Beliya Nos Cape section (Lower Campanian); c) general view of Byala–north section; d) Byala–south section: the uppermost Maastrichtian and the lowermost Danian levels; e) general view of the base of Beliya Nos Cape section (lowermost Campanian levels); f) the Maastrichtian levels north of Beliya Nos Cape towards Byala River mouth (view to north); g) a fault without data for visible displacement north of Beliya Nos Cape; h) thrusted and folded levels of the Byala Formation between Byala–north section and Beliya Nos Cape.