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UPPER CRETACEOUS INTEGRATED BIOSTRATIGRAPHY IN THE WESTERN BELT OF THE VARDAR ZONE

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Abstract: A new integrated biostratigraphic concept of an Upper Cretaceous series near Novi Pazar, Stara Raška region, the Vardar Zone, for Bajevica-Mur and Gradina, is based on the distribution of benthic foraminifers, planktonic microfossils, and calcareous nannoplankton, supported by available information on rudists from Bajevica. The Upper Cretaceous succession in the Stara Raška region is characterized by a transgressive trend. The shallow-water sedimentation was short (uppermost Santonian?–Lower Campanian). Progressive deepening during the Campanian *elevata*, or the CC17 and CC18 Nannoplankton Zones, is indicated by successive deposition of shallow-water limestones and lower-ramp hemipelagic carbonates, and then of basinal pelagic sediments.

Key words: Vardar Zone, Senonian, integrated biostratigraphy, Foraminifera, Algae, Mollusca, nannoflora.

Introduction

Upper Cretaceous sedimentary rocks of the Novi Pazar area, Stara Raška region, the Vardar Zone, have been a subject of different geological investigations, mostly after the Second World War (Mojsilović et al. 1980, cum. bibl.). Published micropaleontological data, however, are scanty, especially that on benthic fauna and flora from shallow-water pre-Maastrichtian rocks which have not been previously studied. Planktonic foraminifers were studied only from deposits a hundred metres thick of the sequences of hemipelagic and pelagic carbonates ("preflysch" auct.). The nannoflora from shallow-water hemipelagic and pelagic sediments researched by P. de Capoa (University of Naples, Italy, in press.), were also studied.

Pre-Maastrichtian macrofauna from the studied localites has been studied by Pejović (1953, 1978; rudists, gastropods) and Rampnoux (1964, 1974; rudists). The first information on planktonic foraminifers in the preflysch part of the unit is given by Rampnoux in 1964. Large Maastrichtian foraminifers are known from carbonate clastics and terrigenous deposits (Radoičić 1988; Petrović & Jankičević 1988).

Geological setting

The Cretaceous sediments in the Novi Pazar area cover Paleozoic rocks assigned to the Carboniferous ("Golija Paleozoic belt"). The Upper Cretaceous succession is observable only in sections of the south-western limb of the Novi Pazar synclinorium, that is in the western part of the Novi Pazar Cretaceous belt (Fig. 1). The northeastern limb of the synclinorium is inverted and in a tectonic contact with ophiolite rocks (Rampnoux 1964; Fig. 1).

The Cretaceous succession consists of basal terrigenous deposits overlain by shallow-water and hemipelagic uppermost Santonian?-Campanian (earlier dated as Santonian) limestones, then a thick sequence of preflysch Campanian/Maastrichtian and flysch post-Maastrichtian deposits (de Capoa et al. 1998). The latter deposits were earlier assigned to the Maastrichtian (Rampnoux 1964, 1974; Petrović & Jankičević 1988).

Bajevica–Mur and Gradina localities are marked in the Fig. 1. Maastrichtian terrigenous rocks from two small outcrops at Alulovići and Kovačevo were also analysed.

Lithostratigraphy

Stratigraphic succession of Bajevica–Mur (Fig. 2)

A Cretaceous stratigraphic section at Bajevica and Mur uncovered on the periphery of Novi Pazar, in Novi Pazar-Ribarići road cuttings on either side of the bridge across the Jošanica (Fig. 1-Ia). The older part of the sequence is found south of the bridge (Bajevica) and the younger part north of the bridge (Mur). Formations newly described in this locality are the Bajevica and Mur Formations, and the Novi Pazar clastics (informal formation).

Bajevica Formation. Its type section is exposed in an outcrop south of the bridge over the Jošanica. The formation is 28 metres thick, composed of two members:

1. basal terrigenous deposits, and
2. shallow-water carbonates.

1. Basal terrigenous deposits (conglomerates and sandstones). Coarse-grained predominantly quartz conglomerate passes gradually into finer-grained sandstone, about 12 metres thick, which passes into shallow-water carbonates. A few beds of fine-grained sandstone shows coaly rashings in insignificant amounts. The likely age of the member is Santonian. Its contact with the underlying Paleozoic unit is not exposed.

2. Shallow-water carbonates. These limestones are 16 metres thick and continuously pass upwards into hemipelagic and pelagic deposits of the Mur Formation. Shallow-water

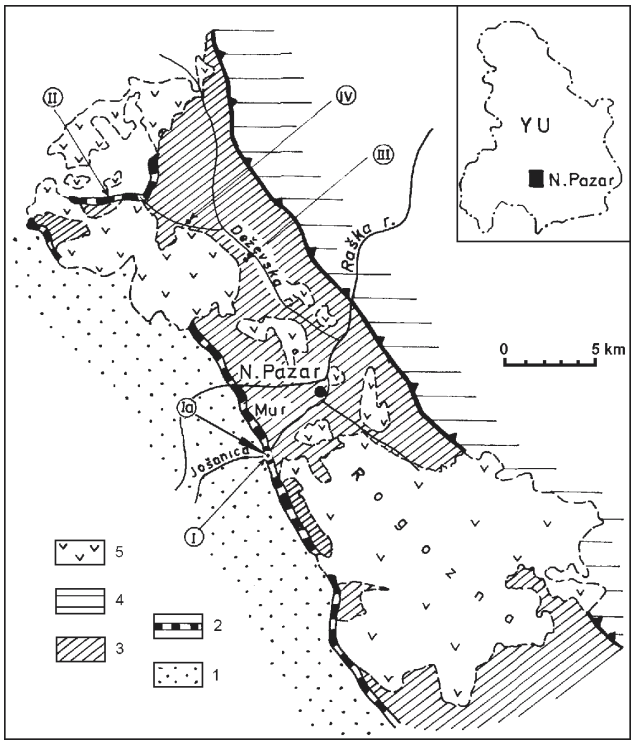

Fig. 1. Detail from Geological map of the Novi Pazar area — Milovanović & Ćirić (1968, simplified). I–IV studied outcrops: I — Bajevica, Ia — The Jošanica bridge, II — Gradina, III — Alulovići, IV — Kovačevo. 1. Paleozoic, 2. basal terrigenous deposits and shalow-water carbonates, 3. "Upper Cretaceous flysch", 4. ophiolites, 5. quartz latites.

low-silty, clayey limestones sporadically in low dolomitized limestones of the Bajevica Formation abound in benthic foraminifers, rudists, dominantly radiolitids, and fewer relatively small hippuritids. According to D. Pejović, even the lowermost nodular limestone bed (no longer exposed), when sampled in 1972, contained numerous radiolitids, easily extractable from this and the overlying bed. D. Pejović describes a new radiolitid species — *Bournonia murensis* from Bajevica limestones. She also mentions: *Bournonia retrolata* (Astre), *Bournonia* sp., *Lapeirouseia zitteli* Douvillé, *L. laskarevi* Milovanović, *L. pervinquierei* (Toucas), *Gorjanovicia* aff. *costata* Polšak, *Radiolitella secunda* Kühn et Andrusov (Pejović 1978). *Bournonia excavata* (d'Orbigny) is now included in this list.

The microfossils assemblage includes: *Idalina antiqua* Munier Chalmas et Schlumberger, *Nummofallotia cretacea* (Schlumberger), *Minouxia conica* Gendrot, *Antalyna korayi* Farinacci et Köylüoglu, *Pseudocyclammina massiliensis* Maync, *Pseudocyclammina sphaeroidea* Gendrot, *Cribrostomoides paralens* Omara, *Dicyclina schlumbergeri* Munier Chalmas, *Cuneolina pavonia* d'Orbigny, *Binconcava bentori* Hamaoui et Saint-Marc, *Nezzazatinela picardi* (Henson), *Moncharmontia apenninica* (de Castro), *Nezzazatinela* sp. 1., *Nezzazatinela* sp. 2., *Spiroplectamina* sp., *Pseudolituonella* sp., *Cornuspira* sp., *Conorboides*? sp., *Spiroloculina* sp., *Rumanoloculina* sp., *Miliolidae* gen. and sp. indet., rotalids and others foraminifers (Fig. 3.2,4,5,12; Fig. 4.1,4–11,13–17; Fig. 5.6–8,11,13–16; Fig. 6.18); rare algae: *Neomeris* sp., *Marinella lugeoni* (Pfender), *Udoteacea* gen. indet. than micronerineae, other gastropods and small solitary corals.

Mur Formation. Type section of the Mur Formation is exposed partly south of the bridge, and largely north of the bridge over the Jošanica. The formation is about 87 metres thick, but the uppermost, about 10 metres thick part is poorly exposed. Its upper boundary is marked by Maastrichtian breccia. The Mur Formation consists of two members:

1. hemipelagic marly limestone with slumped blocks,
2. hemipelagic and pelagic carbonates.

1. Hemipelagic marly limestone with slumped blocks in the upper part. The lowermost beds of the Mur Formation, south of the bridge, are friable low silty marly hemipelagic rocks (at present, a part of the section obliterated by marly detritus) and marly rocks emplacing limestone blocks[1] and clasts from a fractured "perireef" area. The episode ended with the influx of finer material: a thick bed of biolithoclastic limestone was found in the section exposed north of the bridge.

Hemipelagic sediments bear scarce planktonic foraminifers and calcareous nannoplankton. A sample of marl between blocks of shallow-water limestone also contains calcareous nannoplankton (CC17 Zone; de Capoa et al. in press).

Limestone blocks (lateral development of the second Bajevica member) contain mainly large hippuritids, fragments and detritus of colonial corals, and calcisponges. The foraminiferal assemblage is the same, only far less abundant and, characteristically, rotalids and rotaliforms are somewhat more numerous. In this outcrop, many large hippuritids (large fragments from 30 to 40 cm long) are conspicuous in individual blocks or as bioclasts. Dozens of large hippuritids have been recovered in this locality for museum collections (D. Pejović). The identified species are: *Vaccinites atheniensis** (Ktenas), *V. cornuvaccinum** (Bronn), *V. galloprovincialis* (Matheron), *V. gossaviensis* (Douville), *V. sulcatus* (Defrance), *V. vredenburgi* (Kühn), *Hippurites canaliculatus** Rolland du Roquan, *H. heritschi* Kühn, *H. matheroni* Douville, *H. microstylus* Douville, *Hippuritella* aff. *H. lapeirousei* (Goldfuss), *Radiolites squamosus* d'Orbigny (Pejović 1978; asteriscs denote species also mentioned by Rampnoux 1964).

The less abundant microfossil assemblage in slump blocks south of the bridge includes: *Idalina antiqua*, *Nummofallotia cretacea*, *Pseudocyclammina massiliensis*, *Pseudocyclammina sphaeroidea*, *Dicyclina schlumbergeri*, *Cuneolina* gr. *G. pavonia*, *Pseudolituonella* sp., *Conorboides*? sp., *Nezzazatinella picardi, Antalyna korayi, Cribrostomoides paralens*, *Dictyopsella cuvillieri* Genrot, *Sirtina* sp., *Cornuspira* sp., *Miliolidae* gen. and sp. indet. (Fig. 5.2–5,9; Fig. 6.10,13), and algae *Dasycladacea* gen. and sp. indet.

Biolithoclastic limestone from the top of the first member (north of the bridge) contains few planktonic microfossils — poorly preserved rare calcisphaerae — in addition to benthic foraminifers and transported rudists and gastropods: *Idalina antiqua*, *Murgeina apula* (Luperto Sinni), *Dicyclina schlumbergeri, Rotalia reicheli* Hottinger miliolidae, hippurites, acteonellae (Fig. 3.1,13,14; Fig. 4.3). This bed gradually passes into low-sandy hemipelagic and pelagic carbonate of the second member.

[1]note that recent landslides mask the preexisting relationship.

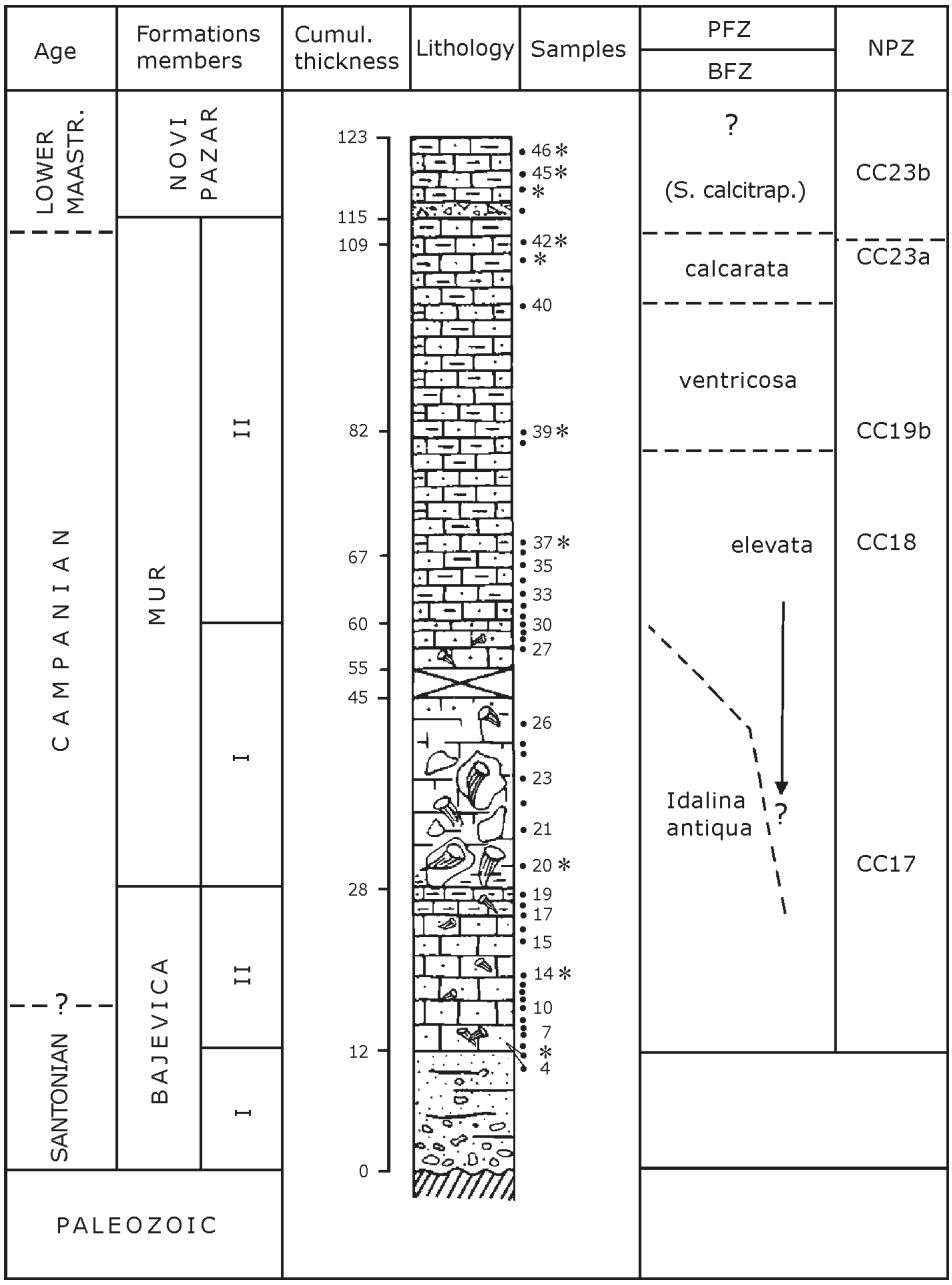

Fig. 2. Stratigraphic column of Bajevica–Mur (asterisks denote nannofossil analysis).

2. Hemipelagic and pelagic carbonates. The biolithoclastic limestone is continuously overlain by low-sandy hemipelagic and pelagic carbonates bearing pithonellae, other calcisphaeruilidae, and few planktonic foraminifers which are more frequent in the marly, locally silty, limestones of the upper part of the member. The lower part of the second member contains: *Andriella trejoi* (Bonet), *Pithonella ovalis* (Kaufmann) and other calcisphaerulids, heterohelicids and *Globotruncana linneiana* (d'Orbigny), *Gl. bulloides* Vogler, *Globotruncanita elevata* (Brotzen), *Gl.* gr. *G. linneiana* (d'Orbigny) (Fig. 7.1). The nannofossil assemblage indicated the CC18 Zone. Besides planktonic microfossils, these beds also contain, very few benthic foraminifers: gavelinellae, sulcoperculinae and lituolid *Tekkeina anatoliensis* Farinacci et Yeniay (Fig. 7.5; Fig. 6.15).

Marly limestones forming the upper part of the second member contain: *Globotruncana linneiana, Gl.* gr. *G. linneiana, Gl. bulloides*, *Gl. ventricosa* White, *Gl. arca* (Cushman), *Globotruncanita stuartiformis* (Dalbiez), *Contusotruncana patelliformis* (Gandolfi), *Globotruncanella* cf. *G. pschadae* (Keller) (Fig. 7.2–4,10). The nannoplankton assemblage indicate the CC19b Nannofossil Zone.

The hemipelagic and pelagic carbonates of the Mur Formation are Campanian representing the *elevata* Zone (Lower Campanian), *ventricosa* Zone (Middle Campanian) and *calcarata* Zone (Middle Upper Campanian). The youngest beds of the upper member (several meters beneath Maastrichtian breccia bed) are Upper Campanian by the contained nannofossils (CC23a Nannofossil Zone; de Capoa et al. in press).

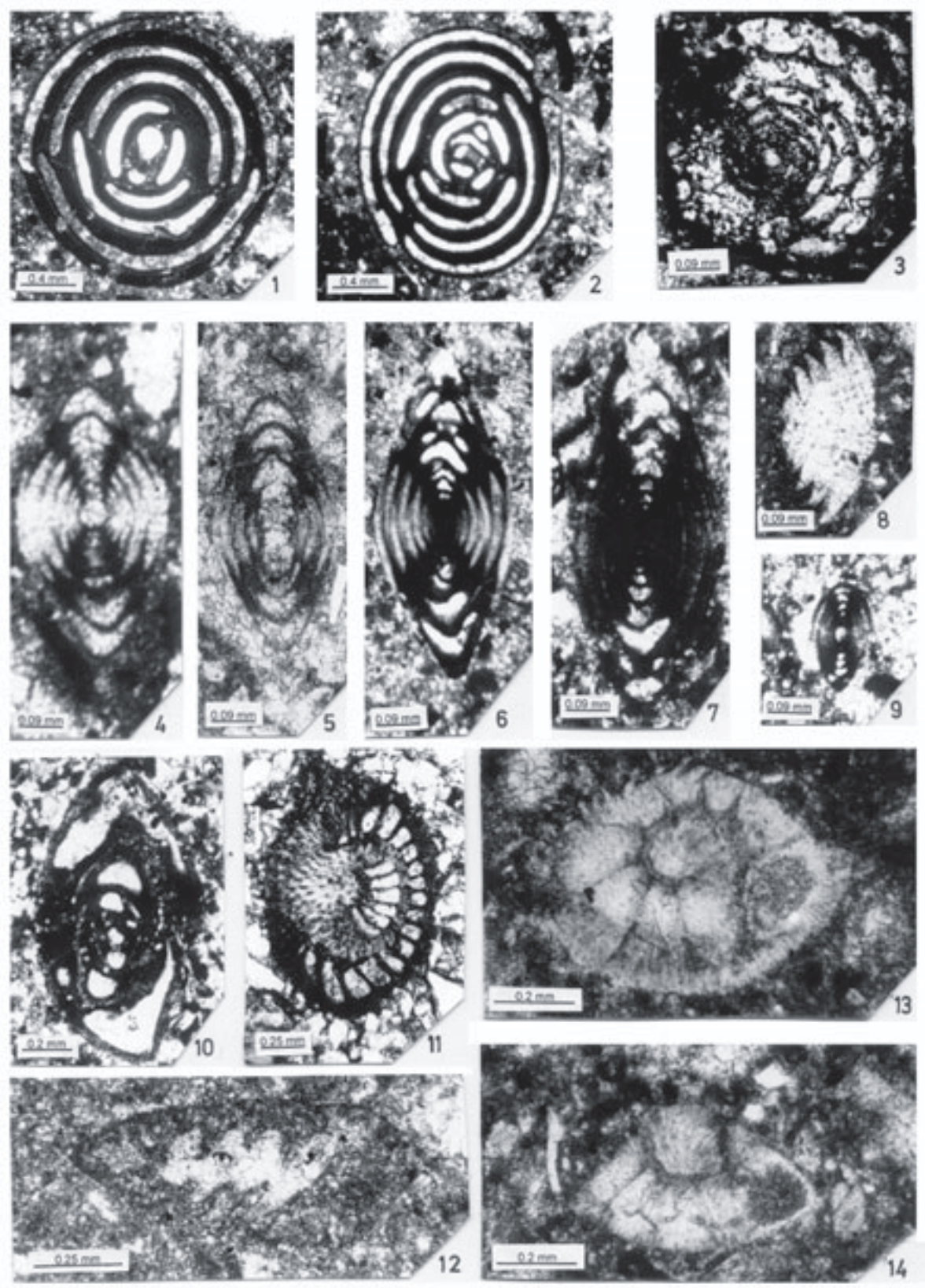

Fig. 3. Benthic foraminifers of the Bajevica–Mur section: 1, 2. *Idalina antiqua* Munier-Chalmas et Schlumberger, samples S30, S7; **4, 5.** *Nummofallotia cretacea* (Schlumberger), sample S6; **12.** *Antalyna korayi* Farinacci et Köyluoglu, sample S4; **13, 14.** *Rotalia reicheli* Hottinger, sample S28. **Benthic foraminifers of the Gradina section: 3, 6–9.** *Nummofallotia cretacea* (Schlumberger), samples S53, S54, S66; **10.** Lituolid, sample S54. **Čekovića millhouse locality: 11.** foraminifer *Laffiteina mengaudi* (Astre), sample S78.

The Novi Pazar clastics

The Novi Pazar clastics is an informal formation because the information on its upper part is lacking. The basal bed (60 cm thick) is biolithoclastic limestone — breccia contains in rudist fragments and debris, large Maastrichtian foraminifers (*Siderolites calcitrapoides* Lamarck, *Orbitoides* gr. *media* (d'Archiac), *Orbitoides* gr. *tissoti* Schlumberger, *Orbitoides* sp., *Lepidorbitoides* sp.) and lithoclasts of varied shallow-water limestone.

Marl-sandy sediments directly over the breccia contain early Maastrichtian nannofossils (CC23b Nannofossil Zone). Consequently, the older part of the Novi Pazar formation is early Maastrichtian in age. This formation probably exceeds hundred metres in thickness.

Stratigraphic succession of Gradina

Cretaceous sediments of Gradina are exposed along a village road on the southern slope of Gradina Hill, north of the Šaronjska reka (river). Many quartz latite intrusions in the area of the Šaronjska and Deževska rivers obscure the succession (Fig. 1). The examined Cretaceous section consists of the Bajevica, the Gradina Formations and the Deževo carbonate clastics. While the Bajevica Formation (both members) is recognized in the examined Cretaceous section, the overlying sediments differ from those outcropping at Mur. The Gradina Formation and the Deževo carbonate clastics are newly described.

The Bajevica Formation. 1. Basal terrigenous sediments (about 11 metres thick conglomerate and sandstone) lie over the Paleozoic and consist predominantly of Paleozoic schist. This member has a middle bed of coarse conglomerate with quartz pebbles, its upper part is of clay-sandy rocks and, unlike those at Bajevica, with a thin cm level of carbonaceous matter. The basal member, like at Bajevica, is most likely of the Santonian age.

2. Shallow-water carbonates. Unlike the type section, the second member begins with a 35 cm bed of accumulated more or less large fragments of rudist tests in dark clay-sand ferruginous sediment (storm bed "coquinite"). A large fragment from this bed is assigned by D. Pejović to *Radiolitella*. Upward follows about eight metres of low-sandy limestone which contains benthic foraminifers, occasional recrystallized udoteacean segments and dasycladacean fragments, and only a few small solitary corals and microgastropods. Notable in this shalow-water limestone is the lack of rudists, unlike the type section. An abundance of white *Idalina antiqua* tests is visible with the naked eye in the first metre of the member (above the 35 cm, "coquinite" bed). Upward occur numerous lituolids (*Pseudocyclammina massiliensis*, *Ps. sphaeroidea*) and much scantier idalinae and other foraminifers.

The microfossil assemblage includes: *Idalina antiqua, Nummofallotia cretacea*, *Ps.* cf. *P. massiliensis*, *Antalyna korayi, Broeckina dufrenoyi* (d'Archiac), *Dictyopsella cuvillieri* Gendrot, *Cuneolina* gr. *pavonia, Nezzazatinella picardi, Dicyclina schlumbergeri, Moncharmontia apenninica, Cornuspira* sp., *Sirtina*? sp., *Conorboides*? sp., *Quinqueloculina* sp., *Lituolidae* gen. and sp. indet., *Miliolidae* gen. and sp. indet. (Fig. 3.3,6–10; Fig. 4.2; Fig. 5.10,12,18; Fig. 6.17), and algae: *Udoteaceae* and *Neomeris* sp.

The lowermost Campanian age of the bed with *Idalina antiqua* is corroborated by nannofossils (CC17 Nannofossil Zone).

The Gradina Formation. The Gradina Formation, continuously overlying the Bajevica Formation, consists of 19 metres thick nodular sandy limestone in alternating compact and thinner softer beds. The basal bed is slumped: wackstone with fine algal and other debris and bioclastic limestones with udoteacean, echinoderm and recrystallized mollusca fragments. The formation is discontionuously overlied by Deževo carbonate clastics.

Lituolids (*Pseudocyclammina massiliensis,* Fig. 6.14) still occur in the lowest two metres, but microfossils are scanty in other beds. Besides a paucity of predominantly small rotaliform foraminifers (*Rotalia* sp. *Pararotalia minimalis* Hofker, Fig. 6.7,9), two or three specimens of other foraminifers are found only in thin sections, a few recrystallized segments and fragments of udoteacean algae, and occasional dasycladacean — *Neomeris* fragment. Small and often completely recrystallized solitary corals are common. Samples from the middle and upper parts of the formation bear few planktonic microfossils: *Hedbergella*? sp., *Globotruncana* sp., *Andriella trejoi*, *Pithonella ovalis*. The upper boundary is marked by a sharp lithological change.

Sediments of the Gradina Formation are Campanian in age, largely lateral equivalents of the Mur Formation.

The Deževo carbonate clastics

Since its upper boundary undefined, this is an informal formation roughly estimated in excess of 100 metres. Its lowest bed is polygenous breccia (which indicates a discontinuity), and lateral slump breccia containing a mixture of limestone with benthic foraminifers: *Nummofallotia cretacea*, *Moncharmontia apenninica*, *Sulcoperculina* aff. *cubensis* (Palmer), sensu Hottinger, *Hemicyclammina chalmasi* (Schlumberger) (Fig. 4.12; Fig. 6.1–4,16) and limestone with abundant planktonic foraminifers: *Gl. linneiana*, *Gl.* gr. *G. linneiana*, *Gl. orientalis* El Naggar, *Gl. arca*, *Contusotruncana fornicata* (Plummer), *Globotruncana arca–Gl. orientalis* (transitional forms), *Gl. bulloides*, *Globotruncana stuartiformis*, *Gl.* cf. *G. ventricosa*, *Marginotruncana* gr. *sinuosa tarfayensis* (Fig. 7.5,6, 9,11,12,13).

Above this a few metres of microbreccia, calcarenites and marly limestones with planktonic foraminifers (*Contusotruncana fornicata*) crop out. This succession is intruded by quartz latite. Subsequently further, turbidity carbonate clastics also crop out: several sequences of breccia, calcarenite, and marly globotruncana limestone with *Globotruncana linneiana*, *Gl. bulloides, Gl. stuartiformis*, "*Globotruncanita angulata–Gansserina gansseri*", *Gl. arca, Globotruncanella* sp., *Archaeoglobigerina* cf. *A. cretacea* (d'Orbigny) (Fig. 7.7). A more or less coarse breccia bed contain numerous clasts of the shallow-water limestones bearing rudists.

The outcropping part of the Deževo carbonate clastics is dated Upper Campanian/Lower Maastrichtian. It is a lateral

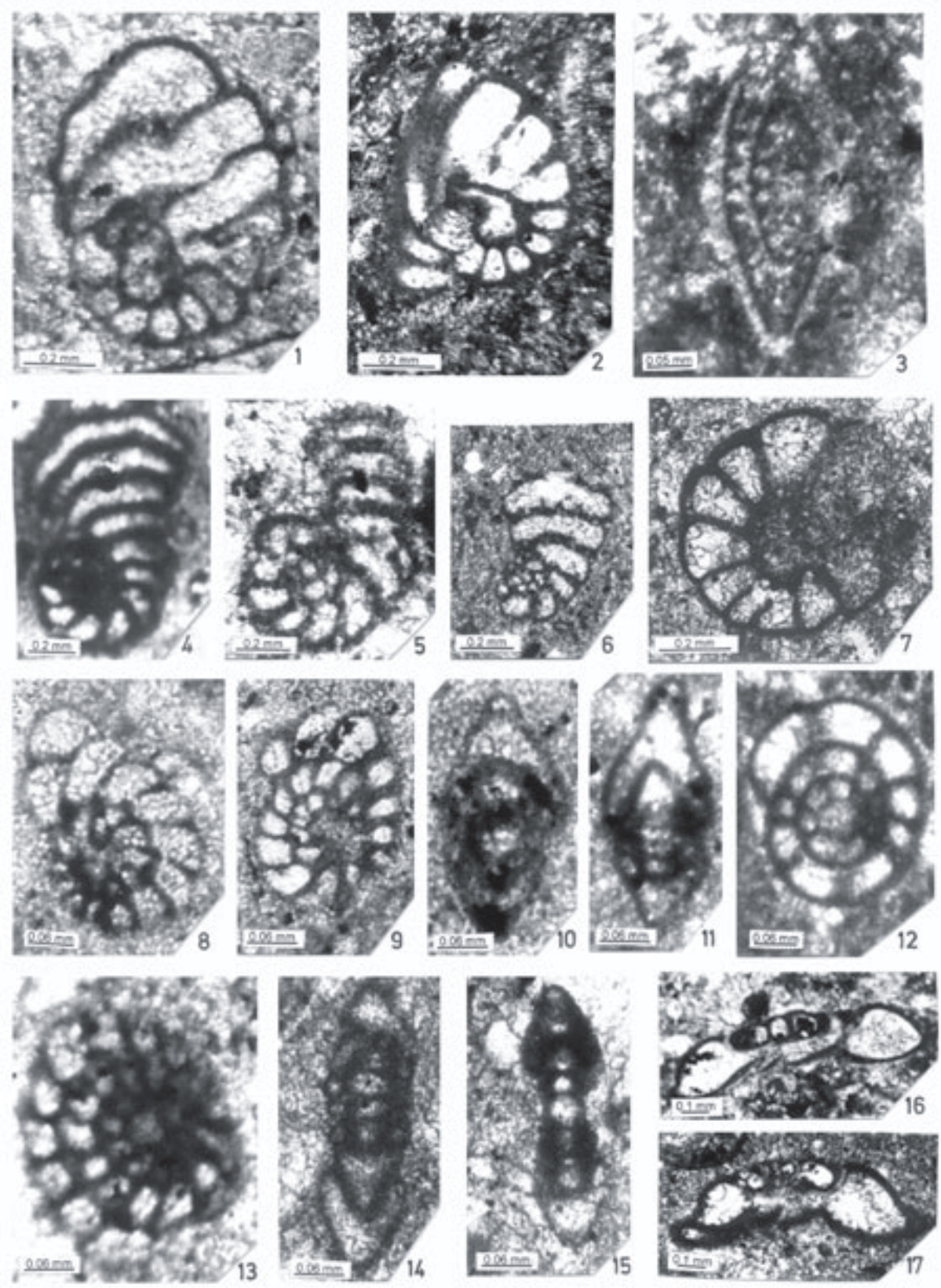

Fig. 4. Benthic foraminifers of the Bajevica–Mur section: 1. *Nezzazatinella picardi* (Henson), sample S11; **3.** *Murgeina apula* Luperto (Sinni), sample S29; **4, 5**. *Pseudocyclammina sphaeroidea* Gendrot, samples S7, S11; **6.** *Pseudolituonella* sp., sample S4; **7.** *Nezzazatinella* sp. 1, sample S6; **8.** *Spiroplectamina* sp., sample S10; **9–11.** *Cribrostomoides paralens* Omara, samples S7, S10; **13–15.** *Biconcava bentori* Hamaoui et Saint-Marc, sample S6; **16, 17.** *Conorboides*? sp., samples S-7, S-11. **Benthic foraminifers of the Gradina section: 2.** *Nezzazatinella picardi* (Henson), sample S53; **12.** *Moncharmontia apenninica* (De Castro), sample S67.

equivalent of the upper Mur Formation and the Novi Pazar clastics.

Some silicoclastic levels outcropping in the same area and probably overlying the Campanian/Maastrichtian Deževo carbonate clastics are dated Lutetian at latest (CP15 = NP15; de Capoa et al. in press).

Outcrops in Alulovići and Kovačevo (Fig. 1)

For the purpose of reconnaissance, only a few samples were collected from Maastrichtian sediments at Alulovići and Kovačevo (Middle-Upper Maastrichtian by Radoičić 1988).

Some beds in the sandstone outcrop, at Alulovići abounded in poorly preserved recrystallized orbitoids. The sandstone also contained sporadic mollusc accumulations. A mollusc collection from this locality includes: *Neritina compacta* Forbes, *Natica transsylvanica* Palfy, *Cerithium alulovici* Pejović, *Cardium duclouxi* Vidal, *Corculum* (Fragum) *cerevicianum* Pašić, *Lucina producta* Goldf., *L. falax* Forbes (Pejović 1953).

Marly sandstone and sandy argilites in the river at Čekovića millhouse in the village of Kovačevo bears, besides foraminifer *Laffiteina mengaudi* (Fig. 3.15), numerous *Cardium duclouxi,* other bivalvia and gastropods (Radoičić 1988).

Maastrichtian sediments of Alulovići and Kovačevo are shallow-water equivalents of the basinal Deževo and Novi Pazar formations — actually parts thereof (more accurate correlations will result from further study). These rocks were interpreted by Mojsilović et al. (1979) as lying in the middle of the flysch column about 300 m thick. They are shown in the geological map Sheet Sjenica (Mojsilović et al. 1979), and Petrović & Jankičević (1988) refer to them as a young flysch series. However, according D. Pejović & R. Radoičić (pers. com.) these sediments of Alulovići and Kovačevo are not flysch. The latest stratigraphical data indicate the post-Maastrichtian age of the flysch (de Capoa & Radoičić 2000).

Paleontological comments on selected foraminifers

Binconcava bentori Hamaoui et Saint-Marc, 1970
(Fig. 4.13–15)

This species was described by Hamaoui et Saint-Marc, 1970 from specimens found in Lebanon and Israel. Those from Lebanon have fewer chamberlets in the terminal coil and less curved septae. My specimens resemble more those from Lebanon in having fewer (14 or less) chamberlets in the terminal coil. The species described was found in Cenomanian rocks, but it also occurs in early Senonian and Campanian of the Apennines, Dinarides, Hellenides, and Provence.

Antalyna korayi Farinacci et Köylüoglu, 1985
(Fig. 3.12)

In the present stage of our knowledge, this species, described from Maastrichtian sediments of Turkey, ranges from Santonian to Upper Maastrichtian (Polavder 2000).

Hemicyclammina chalmasi (Schlumberger), 1899
(Fig. 6.16)

In the type locality, the little known species *Hemicyclammina chalmasi* ranges from Coniacian to Upper Santonian. *H. chalmasi* found in Gradina limestones is Campanian in age (Polavder 2000).

Broeckina dufrenoyi (d'Archiac, 1854)
(Fig. 6.17)

Broeckina dufrenoyi was known only from the type locality, from specimens of the B-generation. In 1975 Cherchi & Schroeder presented specimens of the A-generation from the same locality. The only section of the species in Campanian limestone of Gradina is also of the A-generation (Polavder 1997).

Nummofallotia cretacea (Schlumberger, 1899)
(Fig. 3.3–9)

This is a common species, especially in Mur limestones. Its preservation and size (diameter, thickness) vary. The external test coils are frequently dissolved to the degree that only umbilical plug has been preserved. Oblique sections of such a test remainder strongly resemble trocholina (Fig. 3.8).

Sulcoperculina aff. *S. cubensis* (Palmer, 1934)
(Fig. 6.1–4)

A foraminifer, exactly like the one presented by Hottinger (1966) as *Sulcoperculina* aff. *cubensis*, found in the Campanian of Gradina has been reported only from the Pyrenees; now this is another region of its occurrence (Polavder 1997).

Tekkeina anatoliensis Farinacci et Yeniay, 1994
(Fig. 6.15)

This little known and recently described species from Turkey is found in the Lower Campanian hemipelagites of the Mur Formation, as corroborated by planktonic foraminifers (*elevata* Zone) and nannofossils (CC18 Zone). From Brač Island, this species is presented as "a large coarsely agglutinated similar foraminifer (or okin) to *Navarella juaquini*" which also occurs in Lower Campanian hemipelagic limestones with pitonellae and calcisphaerae (Gušič & Jelaska 1990 — Pl. XI: Fig. 2).

Miliolidae gen. and sp. indet.
(Fig. 5.6–15)

The third most abundant, besides quinqueloculina type and *Idalina antiqua*, are miliolids of planispiral coiling at the final stage of growth**.** Tests of the *Massilina* Schlumberger, 1893 and *Derventina* Neagu, 1968 are characterized by the ball-like early stage developing into planispiral coiling. *Massilinae* have apertures with bifid tooth, and derventinae have dentate aperture. Since these structural features are not visible in the available sections, they are presented as miliolidae of open

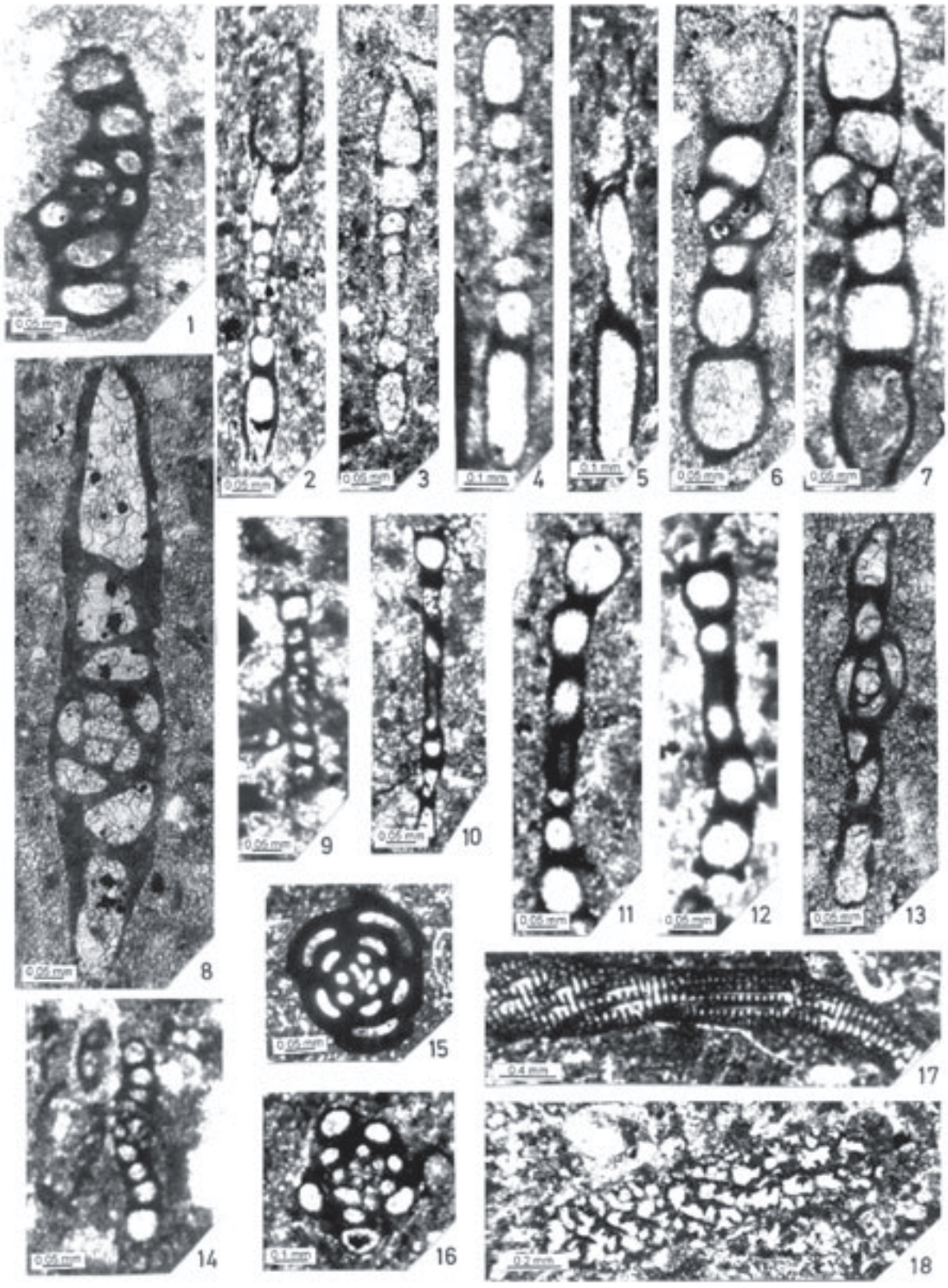

Fig. 5. Benthic foraminifers of the Bajevica–Mur section: 1. *Spiroloculina* sp., sample S6; **2–5.** *Cornuspira* sp., sample S26; **6–9, 11, 13–15**. *Miliolidae* gen. and sp. indet., samples S6, S9, S10, S19, S26: 6,7 — sp. 1; 8 — sp. 2; 9 — sp. 3; 11 — sp. 4; 13 — sp. 5; 14 — sp. 6 (*Spiroloculina*?); 15 — sp. 7 (aff. *Rumanoloculina*). **16.** *Rumanoloculina* sp., sample S17; **17.** *Dicyclina schlumbergeri* Munier-Chalmas, sample S31. **Benthic foraminifers of the Gradina section: 10, 12.** *Miliolidae* gen. and sp. indet., sample S53; 10 — sp. 3; 12 — sp. 4; **18.** *Dicyclina schlumbergeri* Munier-Chalmas, sample S53.

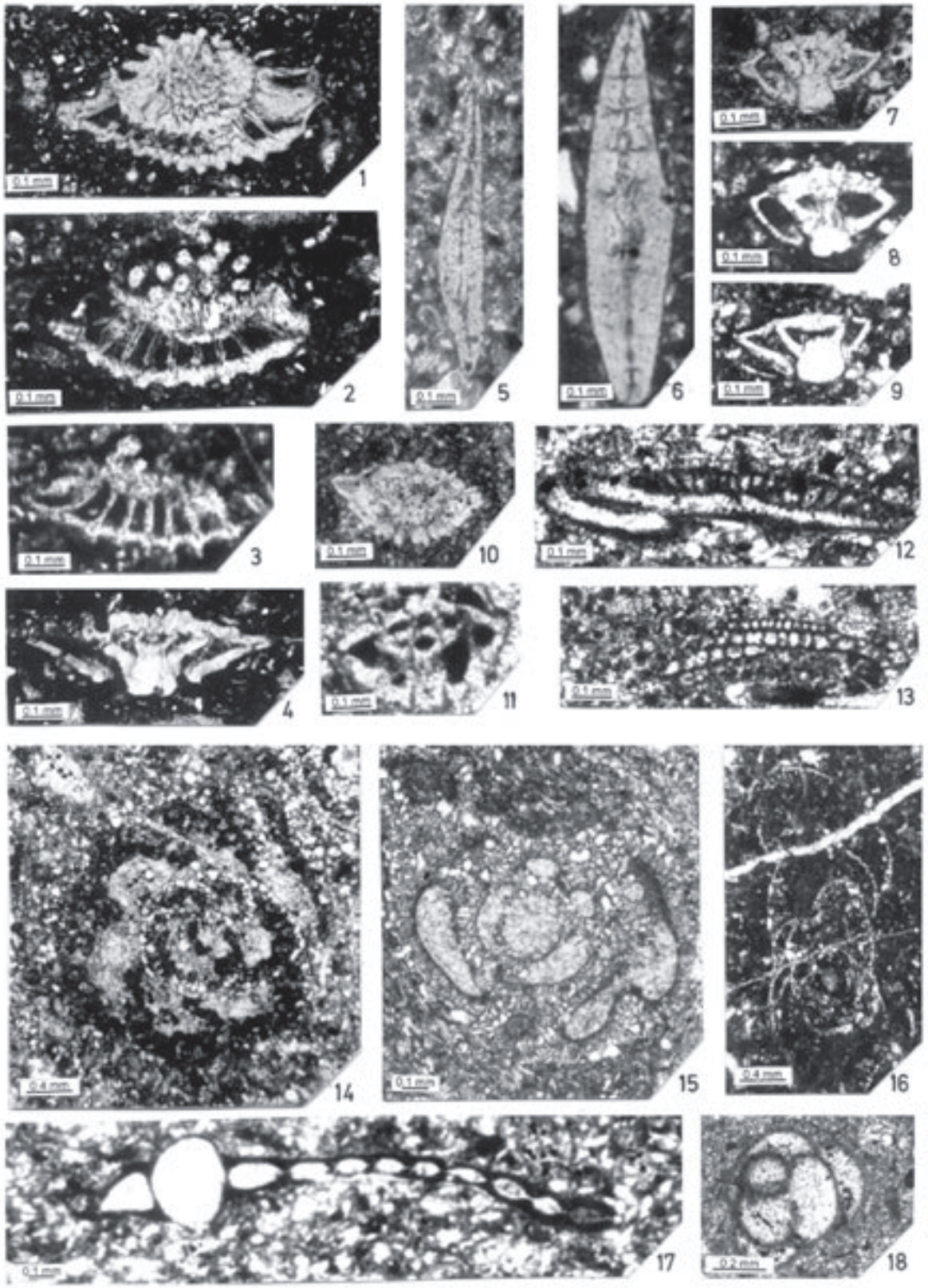

Fig. 6. Benthic foraminifers of the Bajevica–Mur section: 5. *Sulcoperculina* sp., sample S32; **8.** *Pararotalia minimalis* Hofker, sample S28; **10.** *Sirtina* sp., sample S25; **13.** *Dictyopsella cuvillieri* Gendrot, sample S32; **15.** *Tekkeina anatoliensis* Farinaccci et Yeniay, sample S24; **18.** *Minouxia conica* Gendrot, sample S4. **Benthic foraminifers of the Gradina section: 1–4** *Sulcoperculina* aff. *S. cubensis* (Palmer), (sensu Hottinger), sample S68; **6.** *Sulcoperculina* sp., sample S68; **7, 9.** *Pararotalia minimalis* Hofker, samples S65, S68; **11.** *Sirtina*? sp., sample S53; **12.** *Dictyopsella cuvillieri* Gendrot, sample S59; **14**. *Pseudocyclammina massiliensis* Maync, sample S56; **16.** *Hemicyclammina chalmasi* (Schlumberger), sample S68; **17.** *Broeckina dufrenoyi* (d'Archiac), sample S61.

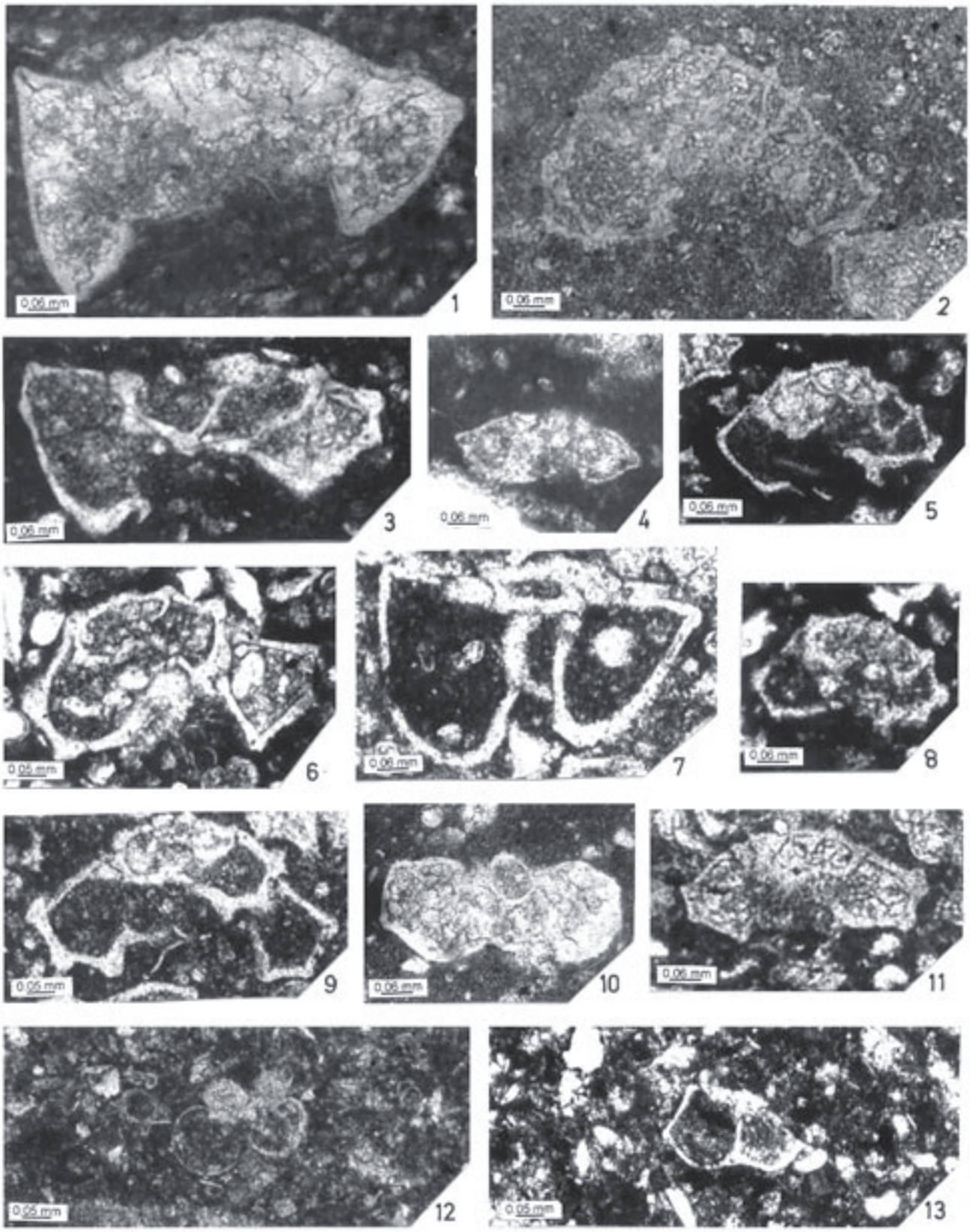

Fig. 7. Planktonic foraminifers of the Bajevica–Mur section: 1. *Globotruncanita elevata* (Brotzen), sample S36; **2.** *Contusotruncana pateliformis* (Gandolfi), sample S40; **3.** *Globotruncana ventricosa* White, sample S40; **4.** *Globotruncanella* cf. *G. pschadae* (Keller), sample S40; **10.** *Globotruncana bulloides* Vogler, sample S40. **Planktonic foraminifers of the Gradina section: 5.** *Globotruncana orientalis* El Naggar, sample S68; **6, 9.** *Contusotruncana fornicata* (Plummer), samples S68, S70; **7.** "*Globotruncana angulata-Gansserina gansseri*", sample S73; **8. 11.** *Globotruncana arca* (Cushman), sample S68; **12.** *Hedbergella* sp., sample S64; **13.** *Globotruncana* sp., sample S64.

nomenclature. Some of them may be new species of one/or another genus.

Biostratigraphical comments

The assemblage of benthic foraminifers in Cretaceous shallow-water limestones of Novi Pazar, includes the following species:

a) distributed throughout the Upper Cretaceous (*Nezzazatinella picardi*, *Dicyclina schlumbergeri*),

b) occurring in the uppermost Turonian or the lowermost Coniacian, and common in the Santonian (*Idalina antiqia*, *Pseudocyclammina massiliensis*, *Hemicyclammina chalmasi*, *Nummufallotia cretacea*); the Turonian dating of some species of this association ought to be confirmed by an analysis of nannofossils.

c) believed to be Santonian or occurring in the Santonian (*Rotalia reicheli*, *Sulcoperculina* aff. *S. cubensis*, *Broeckina dufrenoyi*, *Tekkeina anatoliensis*),

d) known so far from the Maastrichtian — *Antalyna korayi*,

e) small, little known rotaliform foraminifers and varied miliolids having the terminal planispiral stage, possibly including new species.

According to reference information the Santonian age of the studied shallow-water limestones should probably be maintained. A more accurate dating is based on an analysis of nannofossils in the shallow-water limestones and nannofossils and planktonic foraminifers contained in the successive sediments. The shallow-water limestones in this part of the Novi Pazar Cretaceous belt are uppermost Santonian?–Lower Campanian. The range of *I. antiqua* is extended into Campanian, however, it does not have to be its ultimate last occurrence. According to D. Pejović, the above mentioned rudists from Bajevica limestones (and blocks) are known as Santonian/Campanian species.

The assemblage with *I. antiqua* in the Cretaceous successions of Novi Pazar resembles largely the association including Santonian foraminifers of the pre-Pyrenees and Provence, though some of the species are widespread in some other regions. *I. antiqua* from the pre-Pyrenees (Lerida) is commonly mentioned as a Santonian species (Cornella 1977; Hottinger et al. 1989). Cornella mentions it from member five of section "El Barranco de la Font de la Plata", which lies directly under massive Campanian limestones (microfauna in the latter is not mentioned as it was not the subject of her study). An important stratigraphical fact is that orbitoids occur at the top of the third and in the fourth members, beneath the beds with *I. antiqua*. The Cretaceous Stratigraphy Subcommission WGCM field trip guide book, (Caus et al. 1981), contains a revised version of the same section. The same authors state that Cornella's fifth member is equivalent to the lowest part of their unit seven which is entirely Campanian.

In the Cretaceous of Provence, according to Tronchetti (1981), *I. antiqua* occurs in uppermost Turonian and is common in the Upper Santonian. In Provence, the assemblage including *I. antiqua* and *Ps. massiliensis* occurs in the marine Upper Santonian (late Upper Santonian are lacustrine and continental deposits). Facies bearing assemblages of this type, excluding Provence, are not well known. *I. antiqua* is not even mentioned in many publications on Campanian benthic foraminifers.

Depositional environments

The Bajevica Formation is characterized by ramp environments inhabited by rudists, foraminifers and algae.

According to Bandy & Arnal (1960, p. 215), diverse abundant populations of quinqueloculinas, triloculinas, and other miliolids indicate a coastal marine environment. In the lower part of the Bajevica Formation the association with *Idalina antiqua* is autochthonous while in the upper beds it is parautochthonous (floatstone with rudist fragments and debris).

The Early Campanian rise of sea level caused substitution of shallow-water sediments (Bajevica Formation) by lower-ramp hemipelagic carbonates (Mur Formation). The beginning of bottom subsidence is indicated by slumping phenomena.

The sequence with slumped blocks is terminated by thick biolithoclastic or silty limestone bed, at the top of which planktonic microfossils already occur, indicating further deepening of the depositional environment. Subsequently, pelagic sediments are followed by flysch-like and flysch deposits.

Excluding a thin bed of accumulated fragments (most likely carried by a strong tide and deposited in a shallow littoral area), the lack of rudists is notable in the Bajevica Formation (the Gradina Succession). The lack of rudists can be explained by the absence of an important environmental factor for rudists.

Rare benthic foraminifers are parautochthonous in the Gradina Formation, which bears segments, fragments and detritus of udoteacean algae and occasional solitary corals. The occurrence of few planktonic foraminifers in the middle part of the Gradina Formation indicates a slow progressive deepening of the still shallow sea (infralittoral, deeper ramp area).

In the Gradina Succession the shallow-water sedimentation, ends with infralittoral deposits**.** This formation is followed discontinuously by deposition of the turbidite carbonate-clastics.

Conclusion

The oldest Senonian, sedimentary rocks in the western part of Stara Raška (the Vardar Zone) Cretaceous belt lie transgressively over the Paleozoic basement.

The oldest shallow-water carbonates of the Bajevica Formation, believed to be Santonian so far, are dated uppermost Santonian?–Lower Campanian. Shallow-water sedimentation of this part of the Novi Pazar Cretaceous unit was short. The depositional area began to deepen during the Early Campanian (CC17 Nannoplankton Zone) and continued during Middle–Late Campanian and also in Maastrichtian (CC23b Nannoplankton Zone).

Relatively shallow-water proximal basinal sandstones with *Laffitteina mengaudi* and *Cardium duclouxi* at Kovačevo and sandstones with orbitoids and molluscs at Alulovići are lateral

equivalents of part of the Novi Pazar clastics and Deževo carbonate clastics.

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