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Middle Jurassic fossil and depositional record from the area of the Zimevitsa Plateau (West Balkan Mountains), West Bulgaria

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Abstract

Four sections were studied to reveal the fossil and depositional record of the Middle Jurassic from the area of the Zimevitsa Plateau (West Bulgaria). The biostratigraphic framework comes from the ammonite, foraminifera and belemnite occurrences, as well as auxiliary data from brachiopods. The sediments were defined by field works and microscopic observations. Our record includes four lithostratigraphic units, from the base to the top: the Ozirovo Formation (Aalenian), Etropole Formation (Aalenian–Lower Bajocian), Bov Formation (Lower Bajocian–Bathonian) and Yavorets Formation (Lower Callovian). Fossils and sediments displayed a deep-shelf to basin setting during Aalenian and Early Bajocian. Prominent carbonate productivity crisis and deepening was recorded around the Aalenian/Bajocian boundary and throughout the Early Bajocian, followed by a recovery in carbonate sedimentation up to the mid-Humphriesianum Biochron. A prolonged hiatus (submarine stratigraphic gap) until Middle Bathonian Orbignyi Biochron was proved by faunal data. During the Middle–Late Bathonian, the studied area represented a pelagic plateau. It was evidenced by the reduced thicknesses of sedimentary successions due to winnowing processes, sediment starvation and condensation. The resulting sediments are thin Fe-ooidal and glauconitized limestones. Well-developed hardground, combined with high fossil concentration, glauconite and phosphate enrichments, and iron mineralization was recognized at the base of Callovian, followed by stable pelagic carbonate deposition in the Middle Callovian.

Keywords: *fossils, deposition, Middle Jurassic, West Bulgaria*

Introduction

The Zimevitsa Plateau is the highest elevated area of the Ponor Planina Mt. westwards the Iskar River Gorge (West Balkan Mts., West Bulgaria). It is a prominent outlier that is composed of thick Jurassic–Lower Cretaceous rocks. It comprises several distinct late Alpine disharmonic folds with NW-SE structural arrangement (Moskovski 2001), which are developed on Bathonian–Berriasian hemipelagic and pelagic rocks, following upon less deformed Aalenian–Bajocian offshore argillaceous sediments, and virtually unfolded shallow-marine terrigenous-carbonate Lower Jurassic rocks. In terms of its regional stratigraphy, the Middle Jurassic strata from this area are well-defined (e.g. Sapunov and Tchoumatchenco, 1995) and subdivided into four lithostratigraphic units, in ascending order: the Ozirovo, Etropole, Bov and Yavorets Formations. However, several Middle Jurassic localities have recently provided new biostratigraphic and lithological data. The account that follows is an extension of the Middle Jurassic stratigraphic scheme for this region, as giving details that has been unknown elsewhere in the West Balkan Mts. It includes combined Aalenian to Lower Callovian fossil range data (mainly ammonites, belemnites and foraminifera) and sedimentary record, which have been obtained from the best exposed sections from the western part of the area of the Zimevitsa Plateau.

Materials and sections

Here we present the results of the study of four stratigraphic sections: section Dobravitsa-1 (43°01'46"N; 23°14'15"E) and two related outcrops, section near Zimevitsa Village (43°01'00"N; 23°17'40"E), section across the Dobravitsa anticline (43°01'25"N; 23°15'00"E), and section to the SW of Cheparna Summit (43°00'32"N; 23°15'25"E). These sites are sufficiently fossiliferous and stratigraphically linked in order an adequate cross-section throughout the Middle Jurassic to be composed, including a sequence from the top of the Ozirovo Formation (Aalenian) to the base of the Yavorets Formation (Lower Callovian). Section Dobravitsa-1 is previously known exposure (Metodiev and Koleva-Rekalova 2008 and references cited therein), comprising the best development of the

Aalenian in Bulgaria and the Aalenian/Bajocian boundary interval in this region. The other three sections have newly disclosed the stratigraphy of the Bajocian and the Bathonian (including the Bajocian/Bathonian and Bathonian/Callovian boundaries). This work is based on the study of petrographic samples and fossils, which are part of Bulgarian Academy of Sciences collections. Fifty thin sections from nearly each rock type recognized in the field were prepared for facies analysis, and they are the data-source for the microfossil distribution. Approximately 350 ammonites and belemnites were collected, to give the best possible biostratigraphic subdivision and age assessment of the rocks.

Results and discussion

The lowest beds of the Middle Jurassic in the area of the Zimevitsa Plateau comprise a locally preserved 4 m thick succession (section Dobavitsa-1 and the exposures) that is composed of dark stained, irregular hemipelagic marl-shale-limestone alternation of the Bukorovtsi Member of the Ozirovo Formation, which rapidly grades into the carbonate-free shales of the Etropole Formation. Lithologically, this succession mainly consists of silty marls and fine-laminated shales with sideritic concretions and phosphate nodules. Limestones occur as interbeds of micritic mudstones, mudstones to wackestones with re-sedimented iron-ooids and bioclastic floatstones and rudstones. The latter two types appear as distinct shell-beds, having a high value of fossil packing, being rich in ammonites and brachiopods, less rich in belemnites (subordinate bivalves and microfossils also appear but not studied), and recording a few levels of taphonomic condensations. Section Dobavitsa-1 keeps a sequence of valuable Graphoceratidae, and auxiliary Hammatoceratidae, spanning the Aalenian *opalinum* Zone to the Lower Bajocian *discites* Zone.

The lower part of section Dobravitsa-1 includes scattered but straight ammonite succession: *Leioceras opalinum*, *Chypholioceras bifidatum*, *C.* gr. *lineatum*, *Cylicoceras crassicostatum*, *Ancolioceras opalinoides*, combined ranges of *Staufenia*, *Ludwigia* and *Pseudographoceras* species (*Staufenia sinon* - *sehndensis* - *opalinoides* - *discoidea* - *staufensis, Ludwigia pustulifera* - *crassa* - *murchisonae* - *gradata*, and *Pseudographoceras subtuberculata*), accompanied by rare *Bredyia*, *Rhodaniceras*, *Planammatoceras* and *Pseudammatoceras*. This set defines the Aalenian *opalinum* and *murchisonae* Zones. Upwards, the graphoceratid record continues with three thinner developed assemblages comprising distinctive *Brasilia* and *Graphoceras* faunas. It includes *Brasilia* gr. *bradfordensis–gigantea* and several allied *Brasilia* species (e.g. *B. falcifera–bayley–subcava* and *B. nitens–similis–decipiens*), attending examples of *Ludwigella* and *Apedogyria* (*L. arcitenens–rudis–cornu* and *A.* gr. *rugosa–subcornuta*), less common *Graphoceras* (e.g. *G. cavatum, G. formosum* and *G. decorum*), and occasional *Pseudammatoceras* and *Accardia*. These faunas typify the Aalenian *bradfordensis* and *concavum* Zones. The topmost located graphoceratid assemblage includes *Toxolioceras* gr. *mundum–walkeri*, *Reynesella juncta*, *Braunsina aspera* and *Hyperlioceras* gr. *rudidiscites*. It defines the Lower Bajocian *discites* Zone and the incoming of its first members was used for drawing the Aalenian/Bajocian boundary. This assemblage contains also unidentified species of the genera *Euaptetoceras*, *Euhoploceras* and *Fontannesia* that evidence the fade of the Graphoceratidae and Hammatoceratidae, and the advent of the Sonniniidae. The Aalenian–Lower Bajocian faunal spectrum of section Dobravitsa-1 contains also frequently re-elaborated belemnites of *Belemnopsis* gr. *apiciconus*, *Holcobelus* gr. *munieri* and *Brachybelus* (aff. *subbreviformis*), as well as various brachiopods referred to least at ten genera and provisionally recorded by Motchurova-Dekova et al. (2009).

Up section, the Bajocian rocks crop out mainly in the core of the Dobravitsa anticline that faces west into a steep and wide exposure of the Zimevitsa Plateau-side. It contains much more expanded sequence of the Etropole Formation (~90 m thick) that rapidly grades into the basal sediments of the Bov Formation (2–5 m thick grey silty marls). The Etropole Formation includes a locally developed thin-bedded alternation of black shales and siltstones (nearly 35 m thick) that probably grades laterally into indistinctly bedded black shales with scattered sideritic and phosphate nodules. These rocks yielded badly preserved ammonites of the genera *Docidoceras*, *Kumatostephanus* and *Bradfordia* that indicated the Lower Bajocian *laeviuscula* Zone. The range of the Sonniniidae that was recorded at lower stratigraphic levels recedes, but the first Stephanoceratidae and Oppeliidae became visible into the succession. Upwards, this alternation evolves to the shales of the Etropole

Formation and the stratification becomes enhanced by long rows of sideritic concretions. The bulk of this pile of sediments still remains poor on fossils, giving a few stephanoceratid and oppeliid ammonites, as well as some otoitid taxa, indicating the Lower Bajocian *sauzei* Zone: *Bradfordia* gr. *involuta*, *Oppelia* spp., *Otoites* gr. *sauzei*, *Emileia* gr. *brochii* and *Skirroceras* gr. *nodosum*. Scattered belemnites of the genera *Belemnopsis* and *Brachybelus* were also recorded.

Surprisingly, the top part of the Etropole Formation, and the lowest beds of the Bov Formation yielded an ammonite assemblage that clearly referred this interval to the Lower Bajocian. We found nice and fairly common ammonites of the oppeliid genus *Dorsetensia*, composing a range of two main valuable species: *D. romani* and *D. complanata*. Less common, but also significant are the examples of several allied species (e.g. *D. regrediens*, *D. edouardiana*, *D. subtecta* and *D. liostraca*). The age assessment of this interval was supported by the occurrence of *Dorsetensia*-related forms, roughly identified as *Nannina* gr. *deltafalcata*, as well as by *Stephanoceras pyritosum* and *Teloceras* gr. *rauricum*. Sphaeroceratidae were also recorded: *Sphaeroceras brongniarti*, *Chondroceras evolvescens*, *C. Polypleurum*, *Chondroceras* spp. and *Phlycticeras* spp.. Accessorily, huge belemnites of *Megateuthis* gr. *elliptica–longa* and smaller rostra of *Brachybelus* gr. *subbreviformis*, and *Belemnopsis* spp. commonly occur. This fossil association corresponds to the lower half of the *humphriesianum* Zone. It reveals that no discontinuity between the Etropole and the Bov Formations exists, and the total chronostratigraphic extent of the Bov Formation is broader than assumed previously (Sapunov and Tchoumatchenco 1995). A clear discontinuity does really exists, but it cuts out the marls of the Bov Formation and thus concerning in absence the upper part of the *humphriesianum* Zone and nearly all higher Bajocian ammonite zones. We are convinced that this break has a regional extent and can be followed all over the Middle Jurassic strata to the west of the Zimevitsa Plateau. Closely to the south of that area, this gap is further deepening as documented by the total lack of sediments higher than the Lower Bajocian *laeviuscula* Zone until the mid-*macrocephalus* Zone of the Lower Callovian.

The topmost segment of the Middle Jurassic cross-section was evidenced in the cliffs on the flanks of the Dobravitsa anticline, as well as in the sections near Zimevitsa Village and Cheparna Summit. It embraces highly discontinuous, condensed and rapidly varying succession of the Bov Formation (0.95–3.50 m thick) that can be found only in the area of the Zimevitsa Plateau. The very base of these deposits corresponds to narrowly extended beds of dark grey radiolarian-spicule wackestones and iron-ooidal intraclastic floatstones to rudstones with phosphate nodules (reaching up to 0.5 m), surrounding scattered ammonites and belemnites (*Parkinsonia* spp., *Leptosphinctes* cf. *leptus* and *Belemnopsis* gr. *nalivkini*), as well as common benthic foraminifera (*Ophthalmidium kaptarenkoae*, *O. prutensis*, *Meandrovoluta asiagoensis*, *Cornuspira* cf. *tubicomprimata*). This is apparently Upper Bajocian faunal spectrum, and the ammonites indicate the *parkinsoni* Zone. These beds are sharply overlain by red-brown, sandy Fe-ooidal bioclastic-intraclastic rudstones and packstones (thickness ranging from 0.75 to 1.20 m) that yielded a few valuable ammonites from the Middle Bathonian *orbignyi* Zone: *Cadomites orbignyi*, *Procerites mirabilis* and *Wagnericeras* gr. *suspensum*. These data demonstrate that the Lower Bathonian is missing. Therefore, it seems this absence is an extension of the break that we have already noted, except the Upper Bajocian beds that are locally preserved only.

The remaining sequence of the Bov Formation display highly unequal development with common sharp surfaces between the different rocks types observed. More expanded succession (2 m thick) of alternating thin-bedded recrystallized mudstones, sandy marls and wackestones with filaments was recognized in Zimevitsa section. It contains condensed fossiliferous levels with distinctive ammonite faunas and belemnites (*Rugiferites rugifer*, *Wagnericeras* gr. *fortecostatum*, *Wagnericeras* spp., *Siemiradzkia matisconensis*, *Prevalia thressa*, *Paroecotraustes ziegleri*, *Choffatia vicenti*, *Parachoffatia arisphinctoides*, *Grossouvria* spp., *Subgrossouvria richei*, *Belemnopsis* spp. and *Hibolites* spp.). The rocks also yielded valuable record from foraminifers, including benthic and planktonic taxa (*Ophthalmidium terquemi*, *Cornuspira infraoolithica*, *C. orbicula*, *Labalina occulta*, *Globuligerina bathoniana* and *G. oxfordiana*). Both ammonite and foraminiferal assemblages provided an extent that covers the Middle–Upper Bathonian (matching the interval from the *subcontractus* to the *discus* Zone according to the ammonites). This succession is

rapidly laterally reduced to a single bed in the section at the Dobravitsa anticline, comprising ooid-bearing bioclastic-filament wackestones with some ammonites (*Siemiradzkia davitashvilii* and *Thraxites haemussensis*) that indicate the Upper Bathonian "*retrocostatum*" Zone. This development has not been observed in the section near the Cheparna Summit. There, a 2.30 m thick succession of medium-bedded glauconitized bioclastic packstones and wackestones, crinoidal packstones, ferruginized bioclastic-oncoidal packstones to grainstones and oncoidal-bioclastic wackestones with filaments were approximately assigned to the Middle–Upper Bathonian, by the occurrence of planktonic and benthic foraminifera (*Globuligerina bathoniana*, *G. oxfordiana*, *Nubecularia reicheli*, *Ophthalmidium terquemi*, *Glomospira* sp., *and Cornuspira* sp.).

The topmost evidence obtained in this study reached the Yavorets Formation. A thin bed of micritic limestones (filament wackestones) from the very base, was found to be bracketed by hardground surfaces, which are enclosing high faunal concentrations including ammonites and occasionally oriented belemnites (*Grossouvria cheyensis*, *G. variabilis*, *Zieteniceras* gr. *zieteni*, *Catasigaloceras* sp. and *Hibolites* gr. *hastatus*). The ammonites enabled the recognition of partly preserved Lower Callovian *macrocephalus* Zone. Upwards, the Yavorets Formation continues with no change in lithology and the scattered occurrence of hecticoceratid ammonites from the genera *Putelaiceras* and *Rossiensiceras* dated the rocks as Middle Callovian ("*Hecticoceras*" Zone).

Conclusions

The faunas and the lithologies from the Aalenian and the Lower Bajocian, recorded in the area of the Zimevitsa Plateau, have revealed a deposition in low-energy environment (located below the effective wave base), and open deep-shelf to basin setting, with low sedimentation rates and frequently interrupted sedimentary influx. Brachiopod occurrences from this interval probably reflect locally raised and pulsating epifaunal sea-bottom settlements, never recorded before at this level elsewhere in West Bulgaria. A distinct crisis of the carbonate productivity occurred around the Aalenian/Bajocian boundary. This collapse is possibly keeping pace to the imposing of stressful conditions, as fossil occurrences rapidly decreased upwards, becoming extremely poor and benthos-free for a wide extent. It seems that this development was due to gradual subsidence, since sedimentation rates apparently increased during the times of the early Bajocian Laeviuscula and Sauzei Biochrons. After that, a trend towards recovery of the carbonate sedimentation appeared, but it was not long interrupted, approximately in the middle of the early Bajocian Humphriesianum Biochron. Thereafter, an extensive interval of non-deposition until the middle Bathonian Orbignyi Biochron was evidenced. The Middle–Upper Bathonian strata of the area examined are interpreted as being associated with locally developed pelagic plateau, in high-energy environments with intermittently losses of sediment supply and phases of sedimentary starvation. It is evidenced from the development of unusually variegated, condensed and coarse-grained deposits that seem to have a narrow occurrence, since outside the area of the Zimevitsa Plateau these strata grade laterally into increasingly thickening and much deeper basinwards successions. After one more short interval of somewhat uneven deposition (early Callovian mid-Macrocephalus Biochron), the Middle Jurassic continues with relatively stable carbonate pelagic development.

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