Доклади на Българската академия на науките
Comptes rendus de l'Académie bulgare des Sciences
Tome 61, No 1, 2008

GEOLOGIE
Stratigraphie

THE AMMONITE ZONES OF THE TOARCIAN IN BULGARIA – NEW EVIDENCE, SUBZONATION AND CORRELATION WITH THE STANDARD ZONES AND SUBZONES IN NORTH-WESTERN EUROPE

Lubomir S. Metodiev

(*Submitted by Academician T. Nikolov on November 28, 2007*)

Mini Review
Written upon invitation of the Editorial Board

Abstract

A scheme of 9 ammonite zones and 16 subzones for the Toarcian in Bulgaria is given. It is an amplification of the standard put forward by Sapunov in 1968. The biostratigraphy of the ammonite successions has been revised through new bed-by-bed collecting and the critical re-examination of older collections available. It is represented in a generic range chart. This seminal review is founded upon all previous contributions that made possible now the Toarcian marine sediments containing ammonites to be biostratigraphically subdivided in more detail and correlated on this basis with the strata outside the country. It leans on the taxonomic and biostratigraphic investigations of 3 000 ammonites which were collected from 75 localities and sections, situated mainly in the Western and Central Balkan Mts, Western and Central Fore-Balkan. An account from few localities outwards this area, e.g. from SW and SE Bulgaria, as well as some boreholes in the Moesian Platform has been also taken. The subzones are newly defined and described. Some of them are still in working phase and need refinement. The zonal and subzonal set suggested in this work seems to be in Bulgaria like that:

• Upper Toarcian: *Pleydellia aalensis* Zone [divided into *Pleydellia aalensis* and *Pleydellia mactra* Subzones]; *Dumortieria pseudoradiosa* Zone [divided

This work is a contribution to the Project No 1005/00, supported by the National Science Fund, Bulgaria.

into *Dumortieria pseudoradiosa* and *Dumortieria levesquei* Subzones]; *Phlyseogrammoceras dispansum* Zone; *Pseudogrammoceras fallaciosum* Zone; *Grammoceras thouarsense* Zone [divided into *Esericeras fascigerum*, *Grammoceras thouarsense* and *Pseudogrammoceras bingmanni*, Subzones]; *Haugia variabilis* Zone [with presumable subdivision into *Denckmannia* spp. and *Collina* spp. Subzones];

• Lower Toarcian: *Hildoceras bifrons* Zone [divided into *Hildoceras semipolitum*, *Hildoceras bifrons* and *Hildoceras lusitanicum* Subzones]; *Harpoceras falciferum* Zone [divided into *Harpoceras falciferum* and *Harpoceras serpentinum* Subzones], *Dactylioceras (Orthodactylites) tenuicostatum* Zone [divided into *Dactylioceras (Orthodactylites) semicelatum* and *Dactylioceras (Orthodactylites) crosbeyi* Subzones].

The zones and subzones are illustrated by few ammonites from each of them which are shown in four figures. They include many species already listed by previous authors in order to confirm the older records, but the main portion of figured species and specimens were unknown so far. In addition, the Toarcian ammonite successions in Bulgaria are briefly discussed in the framework of the modern palaeogeographic reconstructions.

Key words: Lower Jurassic, Toarcian, ammonite zones and subzones, Bulgaria

Introduction. The marine sediments of the Toarcian in Bulgaria have long been famous for their abundant and well-preserved fossils. This particularly applies to the ammonites which have attracted much attention since the earliest times. Probably the ammonites were the main reason that the Toarcian is one of the earliest determined stages of the Jurassic in Bulgaria. At the very outset, the first evidence which has appeared between 1881 and 1893 came from the geological itineraries that have been made by Toula across the Balkan Mountains Area [1–3]. Several Toarcian ammonite species are listed and figured within descriptions that have been published into these three successive papers. Fifteen years later, in 1908, the Toarcian has been determined to be a stage of the Jurassic System in Bulgaria by Zlatarski [4]. The founding monograph of Zlatarski *"Le système Jurassique en Bulgarie"* contains a schedule of Toarcian ammonite species that gives us an approximate idea about his understanding of the amount of the stage: "*Harpoceras radians* Reinecke sp., *Coeloceras commune* Sow. sp., from Kriva Reka River, near to the village of Beledie Han; near to the village of Lakatnik; from the coomb of Manastirski Dol near to Teteven; near to the mouth of Vassilyovska reka River", "*Harpoceras* aff. *bifrons* Brug., *Harpoceras* cfr. *bicarinatum* Wright, *Stephanoceras* cfr. *annulatum* Sow., from the village of Breze and to the south of the village of Zaguzhene", "*Harpoceras (Ludwigia) aalensis* Zieten, from the hamlet of Ravna, west of Etropole", "*Coeloceras (Dactylioceras)* aff. *anguinum* Reinecke sp., near to the village of Lakatnik", "*Stephanoceras* cfr. *crassum* Young, near the village of Tzerovo". It seems that Zlatarski's concept about the Toarcian coincides with that accepted by Oppel [5] who is the originator of Jurassic zoning.

The subsequent history of exploration of the Toarcian ammonites in Bulgaria has been made by many contributions which have been published in the course of two distinct periods – approximately to the middle of the 1950s and after that. The first period is outlined by the classical papers of Bončev and Tzankov [6], Koen [7], Kamenov [8] and Mandev [9], followed thereafter by the publications of Koen [10], Atanasov [11], Atanasov [12] and Kerekov [13]. There is an agreement in all of these studies that the "Upper Lias" (i.e. the Toarcian) is a lithologically discernible "stage" on the top of the Lower Jurassic. The fossil contents of the stage retained, however, untreated from biostratigraphic point of view. An exception from this time is the original paper of Koen "*The Mesozoic in Bulgaria*" [10], which was the first attempt to do a zonal subdivision of the Toarcian in Bulgaria using the classical ammonite zonal scale proposed by Oppel [5]. This work is also pioneering in correlation between the Toarcian ammonite record from our country and from outside Bulgaria. Koen attempted to make a liaison with some famous Toarcian ammonite localities in Swabia, North-western Germany, Lorraine (NE France), and Britain. He tried to estimate the palaeogeographic importance of Bulgarian Toarcian ammonite faunas.

Literature on Bulgarian Toarcian ammonites from the last 50 years contains many works that have led to the progressive refinement of knowledge. Four papers have initiated the appearance of the modern ammonite zonal standard for the Toarcian in Bulgaria, those by Sapunov [14], Nachev [15, 16] and Encheva [17]. These contributions have been inspired from the acquirement of a new, rich and relatively well-documented material, collected from the Toarcian exposures located near the town of Teteven, as well as from the iron-bearing sediments of the highly elevated Troyan Balkan.

Sapunov [14] introduced 3 ammonite zones for the Lower Toarcian – *Dactylioceras (Orthodactylites) tenuicostatum* Zone [as "Zone of *Dactylioceras commune* (Sowerby)"], *Harpoceras falciferum* Zone [as "Zone of *Harpoceras falcifer* (Sowerby)"] and *Hildoceras bifrons* Zone [as "Zone of *Hildoceras bifrons* (Bruguière)"], and applied one zone for the Upper Toarcian – "Zone of *Lytoceras jurense* (Zieten)". Nachev and Encheva separated three "zones": "Ferruginized limestones – *Harpoceras serpentinum* Sow. Zone", "Limestones with belemnites – *Harpoceras bifrons* Brug. Zone", and "Limy goethite ore – *Lytoceras jurense* Zone" [15–17]. Even unsatisfactory in terms of nomenclature and still based on lithological criteria, and despite the erroneous index designations, these units certainly argued for that the Toarcian is well-divisible by ammonites in the same manner like in the North-western Europe.

Soon after, Sapunov and Nachev [18], Nachev, Sapunov and Stefanov [19–21] and Sapunov [22] described some sections and their ammonites from the Western Balkan Mts, to be followed by Sapunov [23] who published first taxonomic study on the Toarcian Dactylioceratidae in Bulgaria. Consequently, Sapunov's paper "*The ammonite zones of the Toarcian in Bulgaria*" appeared in

1968 [24]. This work contains more than 80 ammonite species from the Toarcian in Bulgaria which were attached to 8 standard ammonite zones. The Upper Toarcian *Lytoceras jurense* Zone has gone out of use. It has been successfully replaced by five empirically established units: *Haugia variabilis*, *Grammoceras thouarsense*, *Dumortieria levesquei*, *Dumortieria moorei* and *Pleydellia aalensis* Zones. Bulgarian ammonite zonal scale was correlated with the zonal standard proposed by Dean, Donovan and Howarth [25] for the North-west European Jurassic Ammonite Province. It formed the basis for the next biostratigraphic studies of the Toarcian in Bulgaria, e.g. Sapunov [26], Sapunov, Tchoumatchenco and Shopov [27–30], Sapunov and Tchoumatchenco [31], and it is in use, as a whole, up to the present.

As new collections have given rise to new empirical evidence during the last decade, it emerged that yet further additions and modifications to the Bulgarian ammonite zonal standard for the Toarcian have become necessary. At first it was the discovery of some species which were unknown in Bulgaria before. Then it was the need for giving of a new meaning to the older records of previous authors from taxonomic point of view. Besides, there were some parts of the zonal set that remained poorly understood. Revision of the older collections and the incoming of a fresh material from newly detected localities caused serious consequences for Bulgarian ammonite standard zones, involving all of them. Several papers of taxonomic purpose added something to the variegated picture of species and genera that can be found in Bulgaria [32–35]. Some zones of the standard were better defined, other refused, and new zonal units came into use [33, 36–38]. The ranges of distribution of many taxa have been extended or reduced [34, 35, 38]. Most recently, it has become aware that there are real opportunities of biostratigraphic discrimination at subzonal level [39]. All of this has led to the currently recognizable succession, now presented into this paper.

Empirical basement of this study. The chain of the Western and Central Balkan Mountains and the adjacent area of the Western and Central Fore-Balkan have within their limits one of the finest outcrops of ammonite-bearing Lower Jurassic rocks in Bulgaria. The Toarcian, which associates with the rocks of the Ozirovo Formation in this region, crops out in several narrow disrupted bands of roughly WNW-ESE and W-E trends running from the state border near the villages of Komshtitsa and Kalotina (Sofia District) in the west and the Shipka Pass in the east, northwards with WNW-ESE strike between the village of Gaganitsa (Montana District) and the Vratsata Gorge, and southwards with the Ponor-Kremikovtsi Jurassic Strip and several isolated exposures located near the town of Slivnitsa and to the south of the village of Gorno Kamartsi (Sofia District) (Fig. 1). Little material of Toarcian ammonites came from the outcrops of the Ozirovo Formation in South-western Bulgaria (near the village of Stanyovtsi, Pernik District) [23] as well as from the low-grade metamorphosed Toarcian sediments that occur in South-eastern Bulgaria (near the village of Zvezdets, Bourgas

District) [40]. Quite recently, the drilling cores of several boreholes, sounded earlier to the north of the town of Montana, have been also found to contain some Toarcian ammonites.

The total account of ammonites that has been taken in this study amounts to 3000 ammonites which were collected from 75 localities and sections which are briefly listed in Fig. 1. They contributed in different manner to the conclusions presented below. Many of them have a character of indications of some of the zonal associations described. Others produced an incomplete ammonite record with partly preserved faunal sequences. The condensed and highly fossiliferous strata are very frequent. However, there are successions which are sufficiently stable in terms of biostratigraphical completeness that enable to follow the Toarcian ammonite assemblages and to do a zoning on them. An approximate picture of nature of the beds, from which the ammonites of the Toarcian in Bulgaria have been obtained, is graphically represented on Fig. 1. More data about the localities and sections are noted below by the descriptions of development and geographical extent the zones and subzones.

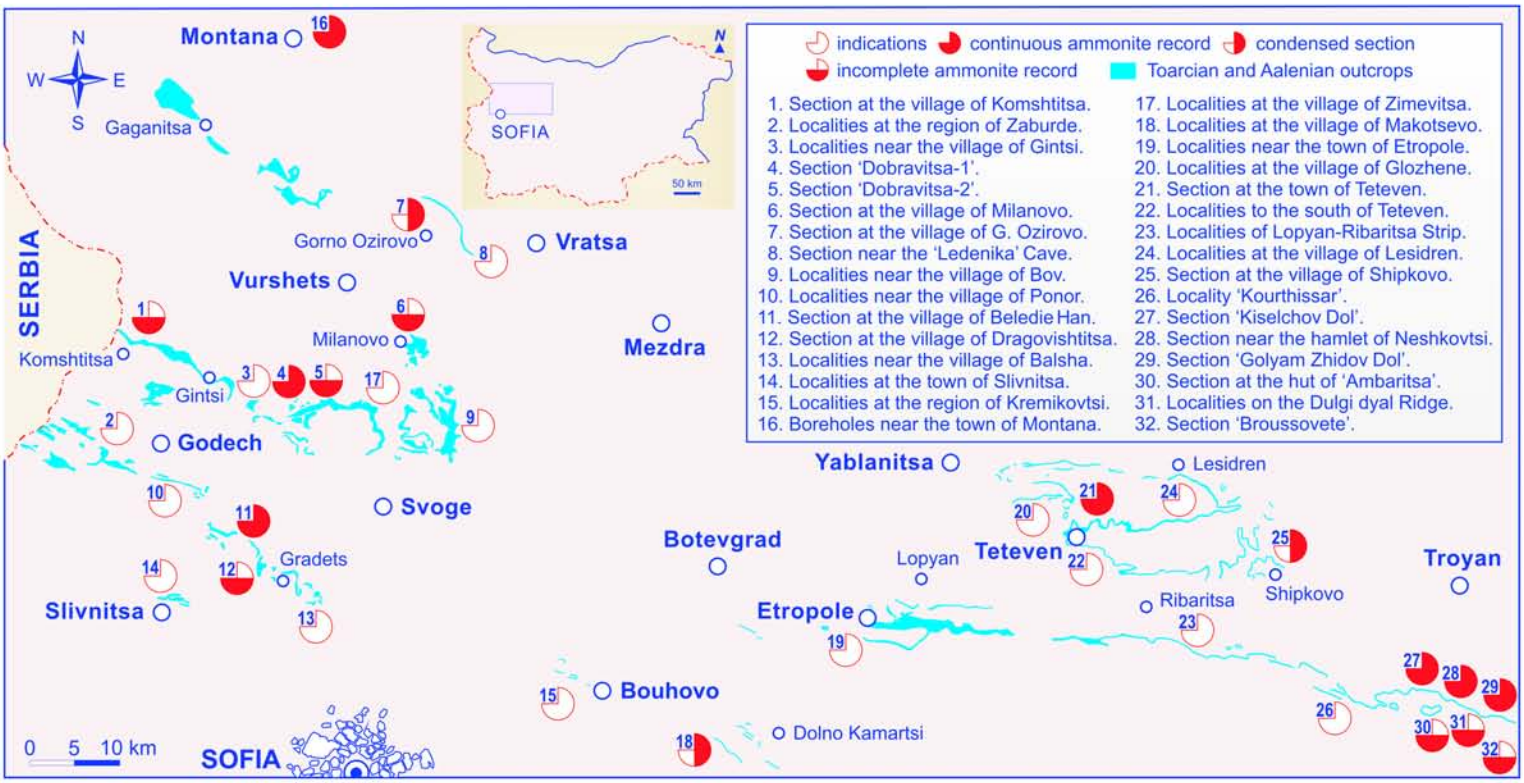
In the Western Balkan Mountains, the most westerly exposed strata containing Toarcian ammonites associate with the uppermost parts of the dark hemipelagic, irregularly-bedded, shale-marl-limestone sediments of the Boukorovtsi Member of the Ozirovo Formation cropping out in Zaburde Region, Vidlich and Ponor Planina Mountains, as well as on the edges of the Iskur River Gorge (Sofia District). Some ammonites have been found in the past from the sections of the Lower Jurassic, located near the village of Komshtitsa [27, 28] and close to the south of the village of Gintsi [18, 28], as well as from several scattered localities in the vicinity of the town of Godech, which were unpublished or recorded from some earlier authors [4, 10, 27], and listed recently [33]. Bed-by-bed sampling has become possible not long ago, from two sections called 'Dobravitsa-1' and 'Dobravitsa-2', situated near the village of Breze, which are the subject of intermittent studies to the present [32–34]. Further specimens occur to the east, from the exposures near the villages of Zimevitsa, Milanovo and Bov [6, 29] (and unpublished data) as well as close to the village of Lakatnik [4, 10] (and unpublished data). Northwards, in Vratsa Balkan, the condensed beds of ooid-bioclastic limestones of the Ozirovo Formation, located in the neighbourhood of the village of Gorno Ozirovo (Montana District), and the exposures close to the 'Ledenika' Cave, were made famous by the researches of Nachev, Sapunov and Stephanov [19–21], Sapunov [23, 24] and the later descriptions of Sapunov, Tchoumatchenco and Shopov [29]. To the south, the Toarcian ammonite-bearing beds are localized in the upper parts of the ferruginized iron-ooidal limestones of the Ozirovo Formation from the Ponor-Kremikovtsi Jurassic Strip (Sofia District). Scattered data are available from the outcrops near the villages of Ponor and Balsha, at the region of Kremikovtsi (unpublished data), as well as from several exposures near the town of Slivnitsa and southerly the village of Makotsevo [27]. Two sections have yielded almost continuous ammonite record from the Toarcian: section at the village of

Beledie Han and the section at the village of Dragovishtitsa. The initial evidence from these sections came from an early time [4, 11, 12], and thereafter from the complex biostratigraphic studies of Sapunov [26], and Sapunov, Tchoumatchenco and Shopov [28]. Recent contributions include those of Metodiev [35], Metodiev and Sapunov [37], and Metodiev, Koleva-Rekalova and Ivanova [38].

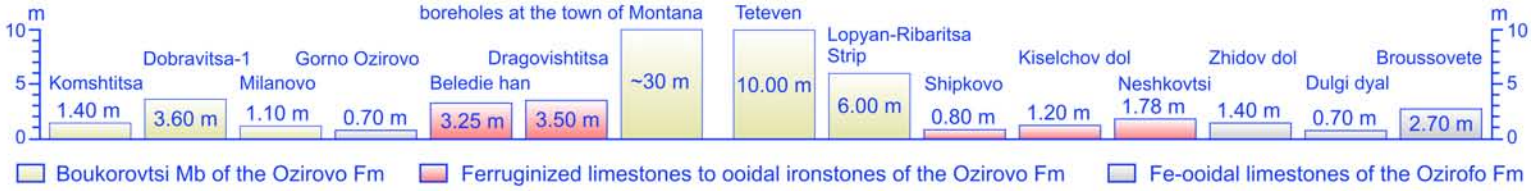
Eastwards the Vitinya Pass, little material appears to be preserved into the exposures of the Boukorovtsi Member of the Ozirovo Formation that occur to the east of the town of Etropole [4, 8, 9, 28]. The ammonite finds became most frequent in the outcrops near the villages of Glozhene and Lesidren (Lovech District) [27], and especially in the vicinities of the town of Teteven from where palaeontological contributions span nearly 100 years [4, 7, 10, 13–17, 22–24, 29–31, 33]. Recently made efforts led to the recovery of many new ammonites which are taken in account into this paper. To the east of Teteven, the Toarcian exposures that belong to the Lopyan-Ribaritsa Strip are restricted and a little amount has been reported [30]. The rapid lateral facial change, from the hemipelagic sediments of the Boukorovtsi Member to the shallow ferruginized ooidal limestones of the homogeneous Ozirovo Formation, that happens more to the east, is underlined by the incoming of the abundant ammonites in the locality around the village of Shipkovo (Lovech District). An excellent collection have been made, partly described previously [13, 23, 24, 30] and now revised for the purposes of this study. After a short distance of lack of fossiliferous deposits, a small locality called 'Kourthissar' is localized close to the east of the Troyan Pass [15, 16]. Afterwards, several excellent exposures are crowded at the catchment area of the Cherni Osam River. This area includes the famous section to the south of the hamlet of Neshkovtsi [15–17, 24, 30], the partly published section 'Kiselchov Dol' which repeats as lithology the previous-one [33], recently dismantled exposure of a section 'Golyam Zhidov Dol' [33, 35], and several sections found to the south of the hut of Ambaritsa, on the Dulgi Dyal Ridge and at the place named 'Broussovete' [16, 30]. Eastwards the massive of the Botev Peak, some isolated localities which are probably useful for biostratigraphic studies occur [24], but they are still poorly known and therefore beyond the scope of this paper.

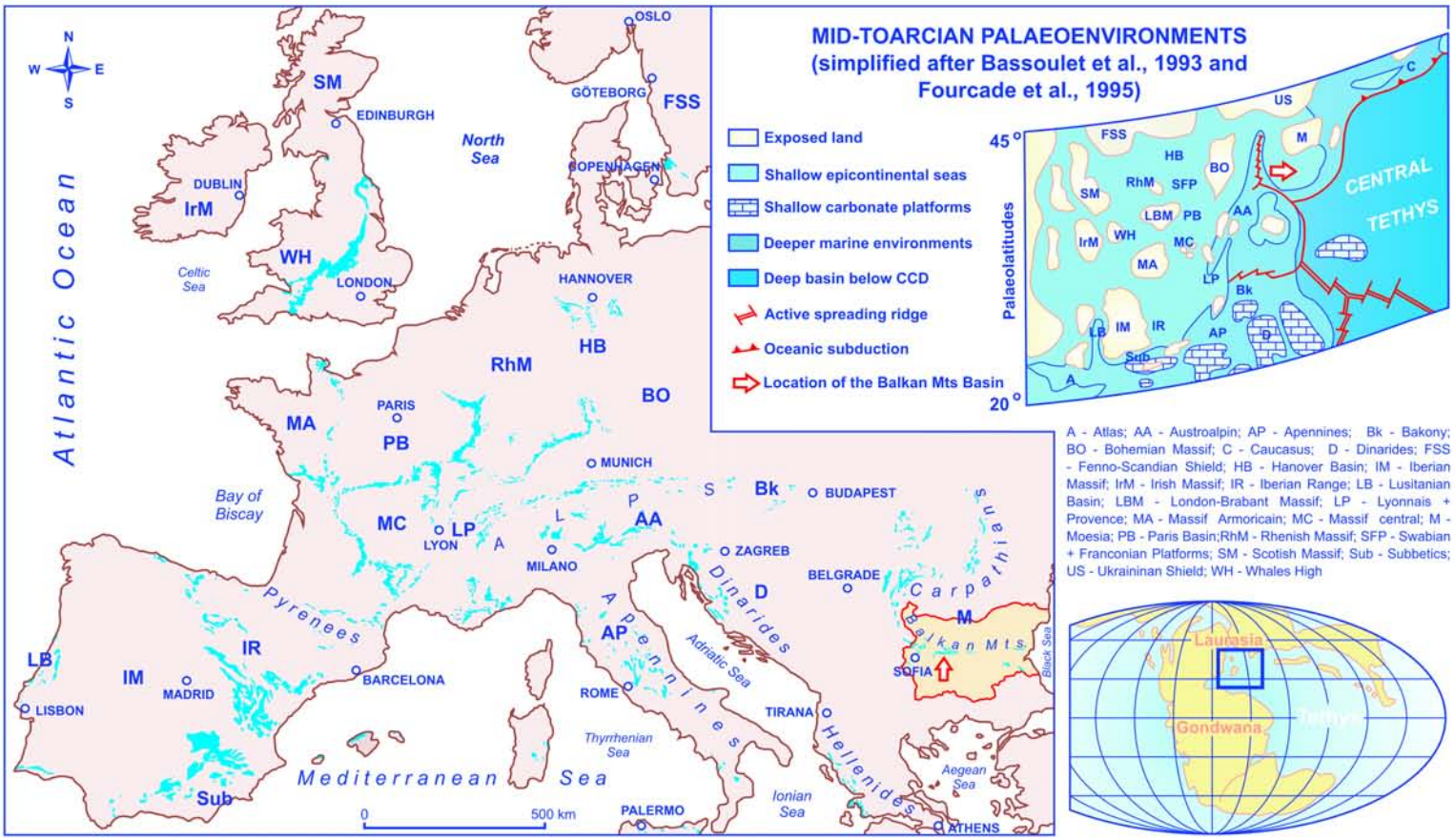
At the end of this short synopsis, it is compulsory to do also a brief analysis of the lithologies and the thickness of the Toarcian sediments which are giving the basis of this study. In behalf of the current research, it is required in order to estimate the validity of the obtained biostratigraphic results. On the other hand, this analysis will give better idea about the rocks from which the main portion

Fig. 1. The approximate exposures of the Toarcian rocks over the area of the Western and Central Balkan Mts, Western and Central Fore-Balkan (Bulgaria) given with reference of major localities and sections yielding ammonites for this study (upper part). The middle represents the thickness distribution of the Toarcian sediments in several selected sections of the same area. The Lower Jurassic outcrops in Europe, drawn together with simplified palaeogeographic reconstruction of the western part of the Tethyan real as supposed for the Toarcian age, with location of the Balkan Mts Basin (lower part) →



Thickness distribution of sediments of the Toarcian in several sections from the Balkan Mountains



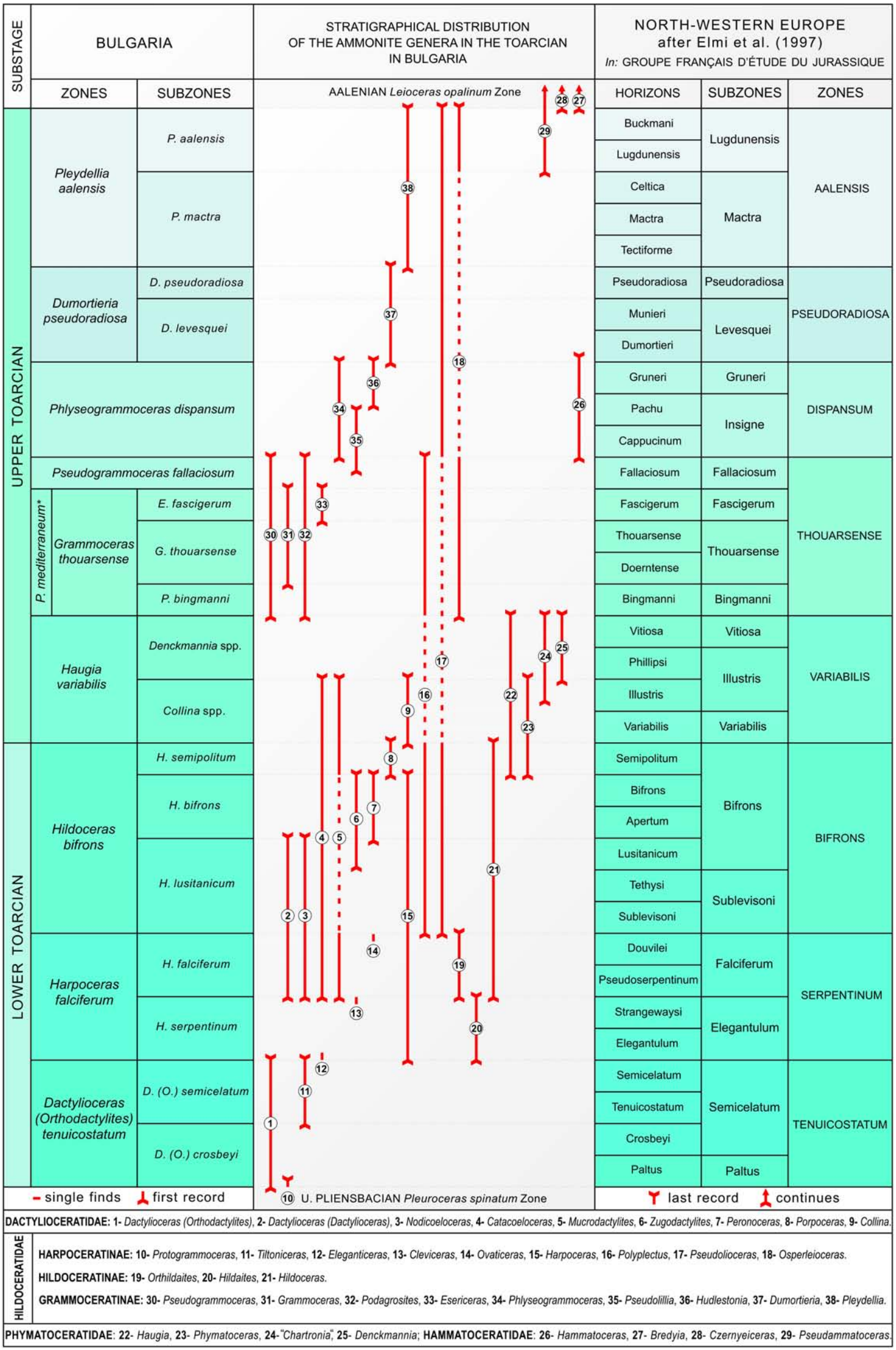


of Toarcian ammonites in Bulgaria comes from. It has been done on 15 selected sections which presumably reflect sedimentary and biosedimentary framework of the stage (for reference, see also the middle of Fig. 1).

As it has become evident, the sediments of the Toarcian in the Balkan Mts Area are represented by two main facial types: (1) dark-coloured alternating marls, shales and limestones (Boukorovtsi Member of the Ozirovo Formation), (2) iron-ooidal limestones and ooidal ironstones (homogeneous Ozirovo Formation). The first type consists of offshore ferruginous marls and grey fine-laminated ferruginous shales which are intercalated by varied limestones: micritic limestones (mudstones), mudstones to wackestones with scarce fossils, wackestones to packstones often with phosphatic ooids, somewhere iron-ooidal limestones (wackestones to packstones) with common fossils, and bioclastic floatstones and rudstones (shell-beds). The fossil component is dominated by ammonites and belemnites, and the brachiopods and bivalves are of less significance. The second type has recently been referred to the "Minette type ironstones" which is well-known from many localities in Europe [38]. It is represented by yellowish to red-brown, ferruginized, bioclastic, iron-ooidal limestones (wackestones, packstones and packstones to grainstones) and beds of ironshot. The bivalves, belemnites and brachiopods are usually the main macrofossils present. Ammonites occur in smaller amount than the other fossil groups. Commonly, the fossils constitute distinct shell-beds (rudstones).

Composed diagram of the thickness distribution of the Toarcian (Fig. 1) displayed a wide variation of the total thickness of the stage both in two facial types, but as a whole the Toarcian is thinly developed. The thickness of the Toarcian in the Boukorovtsi Member varies from 1.10 m (section at the village of Milanovo) to 10 m (section near the town of Teteven). An exception has been recently established from the boreholes near the town of Montana where it seems that the total thickness of the stage is about 30 m. The Toarcian is normally less thick in the homogeneous Ozirovo Formation – from 0.70 m in the holostratotype of the Ozirovo Formation at the village of Gorno Ozirovo, where the ammonites come from just two beds, to 3.50 m in the section at the village of Dragovishtitsa. Two factors seem to be responsible for the small thickness of the stage – synsedimentary condensation processes, and mechanical/chemical compaction during late burial diagenesis (unpublished data of Koleva-Rekalova). It was evidenced that the Toarcian sediments are a product of reduced and often interrupted sedimentary influx. Besides, shell-beds which are the main source for fossil collection appeared to be concentrated and amalgamated as a result of winnowing and transportation of fossils by strong currents even storms in a shallow setting. The bulk of the

← Fig. 2. The ammonite zones and subzones of the Toarcian described in this study (left) represented against the ammonite zonal standard of the North-western Europe (right) and outlined by the stratigraphical distribution of the Toarcian ammonite genera in Bulgaria (middle)



DACTYLIOCERATIDAE: 1- *Dactylioceras (Orthodactylites)*, **2-** *Dactylioceras (Dactylioceras)*, **3-** *Nodicoeloceras*, **4-** *Catacoeloceras*, **5-** *Mucrodactylites*, **6-** *Zugodactylites*, **7-** *Peronoceras*, **8-** *Porpoceras*, **9-** *Collina*.

HILDOCERATIDAE

HARPOCERATINAE: 10- *Protogrammoceras*, **11-** *Tiltoniceras*, **12-** *Eleganticeras*, **13-** *Cleviceras*, **14-** *Ovaticeras*, **15-** *Harpoceras*, **16-** *Polyplectus*, **17-** *Pseudolioceras*, **18-** *Osperleioceras*.

HILDOCERATINAE: 19- *Orthildaites*, **20-** *Hildaites*, **21-** *Hildoceras*.

GRAMMOCERATINAE: 30- *Pseudogrammoceras*, **31-** *Grammoceras*, **32-** *Podagrosites*, **33-** *Esericeras*, **34-** *Phlyseogrammoceras*, **35-** *Pseudolillia*, **36-** *Hudlestonia*, **37-** *Dumortieria*, **38-** *Pleydellia*.

PHYMATOCERATIDAE: **22-** *Haugia*, **23-** *Phymatoceras*, **24-**"*Chartronia*", **25-** *Denckmannia*; **HAMMATOCERATIDAE**: **26-** *Hammatoceras*, **27-** *Bredyia*, **28-** *Czernyeiceras*, **29-** *Pseudammatoceras*.

ammonites has been recognized to be reworked and resedimented. Notwithstanding, thickness reduction is rendered basically to the post-burial pressure solution (chemical compaction) of the sediments which is documented by frequent stylolite structures and swarms of fine clay seams forming wider responsive zones. For objective reasons, sometimes it is very difficult to do a zoning. It is also an effort to find some evolutionary relationships. Frequently the ammonite associations are mixed, preserved in thin beds or incomplete. Nevertheless, the ammonite record of the Toarcian in Bulgaria is proved to be complete in satisfactory way.

Few more lines finally are necessary to be said about the provenance and repository of material used for the present paper. This work has been taken on collections of several predecessors as well as on the personal collection of the author himself. About half of the ammonites have been collected between 1930s and 1970s which was a period of extensive field works, associated first with strengthened geological mapping and prospecting, and then by biostratigraphic studies of the Jurassic in Bulgaria. This portion includes the kindly loaned material of Prof. Ivo Sapunov from the Western Balkan, Teteven Area and Troyan Balkan. It consists also of the ammonites of Prof. Ivan Nachev and Dr. Simeon Kerekov from Troyan Balkan, Dr. E. Koen (Teteven Region), Prof. Boyan Kamenov (from Etropole Region and the Ponor-Kremikovtsi Jurassic), as well as of some specimens of Mr. Julius Stefanov from the Zaburde Area. Unfortunately the originals of Prof. Zlatarski have not been certainly found. The present investigation is also benefited from the collections of several small graduation works. Specimens studied are housed in two institutions – St. Kliment Ohridski University of Sofia and Geological Institute of the Bulgarian Academy of Sciences.

Palaeogeographic notes. In the Balkan Mts Area, the Toarcian sedimentary facies came into the general depositional framework of the Lower Jurassic lithological record, after an evolution from initially isolated lacustrine settings (Hettangian) to rapidly expanded shallow-marine sandy-carbonate-bioclastic environments (Sinemurian onwards). This progress resulted from the gradual and continuous extension of the marine regime that happened during the early Jurassic time. The variegated pattern of the Toarcian sediments both in lithology and thicknesses talk about an unstable configuration of the palaeogeographic background and sensible bathymetric differentiation which were probably controlled by tectonics-eustatic factors of local or regional scale. In this context, the assumption that the Lower Jurassic Series from the Balkan Mts Area was accumulated into a highly fragmented epicontinental basin of straight-like configuration has been made [41]. This basin was opened on the southern edge of the Moesian Early-Middle Jurassic Platform. According to the recent palaeogeographic reconstructions, it was developed due to the extensional faulting of the northern passive margin of the Tethys Ocean during the Early Jurassic [42, 43]. It seems that in the beginning of the Toarcian this basin became part of a broad epeiric sea, extended northwards and westwards from the Central Tethys and covering much of Western and South-eastern Europe (Fig.1). This is particularly emphasized by

the mass-incoming of the ammonites into the fossil assemblages of Toarcian age in Bulgaria, because the beds downwards through the Lower Jurassic are less and less containing ammonites. It is obvious that the Toarcian time was an age less restrictive regarding the ammonite diversity both in environmental and burial aspects. That means the ammonite record from the Toarcian is more favourable to doing a liaison with the contemporaneous ammonite successions outside the country.

In this connection, there are several attempts for estimation of the Toarcian ammonite occurrences in Bulgaria in the light of its palaeobiogeographic affiliation and the relationships with the rest of Europe. Credit must go first to Koen [10] who believed in the resemblance between the ammonite faunas from the Toarcian exposures in the area of Teteven and Etropole and those from Lombardy, Rhone Basin, Swabia, Lorraine, North-western Germany and England. He argued that the Toarcian sediments of this region take a part in "the coastal zone of the Mediterranean-Alpine Jurassic Sea". This conclusion is somewhat reasonable, even being drawn on inadequate evidence of a local value. The first comprehensive discussion on palaeobiogeographic state of the Toarcian ammonites in Bulgaria consequently followed after their arrangement into the Bulgarian ammonite zonal standard. Sapunov [44] maintained them to be south-eastwardly extended record of the North-west European Jurassic Ammonite Province as determined by Dean, Donovan and Howarth [25]. In this manner he found that this palaeobiogeographic unit ought to be expanded and it is more balanced to use it in wider limits including eastwards the ammonite record from the Caucasus. That led to the introduction of the European Caucasian Lower Jurassic Ammonite Province within the framework of the Tethyan Ammonite Realm. It merges the ammonite-bearing beds of the Lower Jurassic from the British Isles, the Paris Basin and the borders of Massif Central, the Jura Mountains, Germany and Poland, the Carpathians (pars), the Balkan Mountains, the Russian Platform, Crimea and the Caucasus. This unit is outlined to stand out against the biosedimentary record from the countries to the south-west and the south-east. It came to be known quite a while ago that the ammonite sequences in Portugal, Spain, the Pyrenees, Italy, the Alps, as well as in the Dinarides, Hellenides, North Africa and Asia Minor have their own pattern both in taxonomic composition and the relative time ranges of ammonite species and genera. That was Sapunov's motive to accept one more palaeobiogeographic unit to be used – the Mediterranean Lower Jurassic Ammonite Province as proposed by Dean, Donovan and Howarth [25] to incorporate the ammonite record from further south.

The above referred concepts about the provinciality of the Lower Jurassic ammonite occurrences in Europe essentially follow the long standing ideas convincing of the palaeogeographic differentiation of their surrounding facies that come up at the present to a large amount of literature. Today, there is a general agreement that such distinction is valid and it has a latitudinal pattern [42, 43]. It is apparent that the European Caucasian Lower Jurassic Ammonite Province

associates roughly with the northern margin of the Tethys, whereas the Mediterranean Province is allied with the southern-one. The main argument for that are the two zonal scales which are in use in Europe actually as summarized by Elmi et al. (In: Groupe Français D'Étude du Jurassique) [45]. The divergence in ammonite distribution is obvious from the opposite sides of the Tethyan suture which can be followed from the Bay of Biscay through the middle of the Alps, with an interruption below the Pannonian Basin, via the line Belgrade-Skopje-Thessalonica to the Cycladic Isles and Asia Minor. Meanwhile, the provincialism of the ammonite faunas seems to be of lower amount than thought earlier, especially the Toarcian itself. It has already been confirmed from many European localities as well as by some recently published data from Bulgaria [33, 34]. There is no doubt that the ammonite record in Bulgaria is European Caucasian, but there is also a sensible Mediterranean influence (further details are given below). It means that even retained so far and used in this paper as well, this conventional palaeobiogeographic nomenclature needs to be reconsidered.

The ammonite zones and subzones of the Toarcian in Bulgaria. The next account that follows is given in respect to the criteria useful for recognizing the zones and subzones used in this study, together with brief details of its development and geographical extent in Bulgaria. Some data concerning the introduction and the first use in Bulgaria of each unit are also stated, followed by subsequent changes in meaning where they exist. The Toarcian ammonite zonal and subzonal set is correlated with the zonal scale proposed by Elmi et al. [45] and enhanced by the range-chart of the genera and subgenera which are found in Bulgaria (Fig. 2). Some examples of the index species and other co-occurring taxa are shown on four figures (Figs 3–6). In the scale here presented, the zonal units are mainly defined in terms of the ranges of genera. For instance, the *Harpoceras falciferum* Zone corresponds to the range of the genus *Harpoceras*, the *Dumortieria pseudoradiosa* Zone to that of the genus *Dumortieria*. This is an advantage for doing an ammonite zonation and age determination of the Toarcian rocks because the zones can be easily recognized, in spite of the cases of quite poorly preserved or very fragmentary ammonites which are too frequent in Bulgaria. In its part, the subzones are drawn on combined criteria both of the ranges of species and genera. For example, the *Harpoceras falciferum* Subzone corresponds to the combined ranges of the genera *Harpoceras* and *Hildaites* with lower limit which has been traced by the first appearance of four more genera and one subgenus: *Orthildaites*, *Mucrodactylites*, *Nodicoeloceras*, *Catacoeloceras* and *Dactylioceras (Dactylioceras)*. The nominations of the index species of the subzones have been made according to the practice widely accepted from abroad. This is believable to be more balanced approach which is more keeping with the tradition and facilitate the correlations. On the other hand, it is provoked from the inequality of the state of knowledge in Bulgaria and outside the country, in full consciousness that this biostratigraphic interpretation goes after many such studies which have already done in Europe.

The extent of the Toarcian Stage in Bulgaria by ammonites is defined in the same way as in the North-western Europe. It is closed between the first appearance in abundance of the genus *Dactylioceras* on the base and the last occurrence of the genus *Pleydellia* on the top. The lower and the upper boundaries of the stage are one more time discernible by the common rarity of the ammonites from below and above. A two-fold substage subdivision of the Toarcian is accepted herein in order to keep the priority of Buckman [46] who first introduced the names "*Whitbian*" and "*Yeovilian*" to provide a means of subdividing the Toarcian Stage. As it was pointed out by Dean, Donovan and Howarth [25], since then they have been found to be useful as substages because the limit between them reflect the convenient demarcation between the disappearance of the latest representatives of the subfamily Hildoceratinae and the mass-incoming of the ammonites of the family Phymatoceratidae.

L O W E R T O A R C I A N

***Dactylioceras (Orthodactylites) tenuicostatum* Zone**

Index species. *Dactylioceras (Orthodactylites) tenuicostatum* (Young & Bird, 1822). According to Howarth (1973, p. 258) [47] the holotype is known to be lost. The two topotypes figured by Buckman (1920, pl. 157; 1927, pl. 157A) [48] were also found to be lost [47]. A neotype (Natural History Museum London No C.77812) was designated and figured by Howarth (1973, p. 258, pl. 5, fig. 1) [47]. It comes from "bed 22" at Port Mulgrave harbour, near Whitby (Yorkshire, England).

The only figured specimen of index species of the zone so far in Bulgaria is that of Sapunov (1963, pl. 1, figs 1, 2; 1968, pl. 1, figs 1a, b) [23, 24], from the Boukorovtsi Member of the Ozirovo Formation close to the north of the town of Teteven. One example, from the condensed Lower Toarcian of the holostratotype of the Ozirovo Formation at the village of Gorno Ozirovo is figured in this paper (Fig. 3b).

Nomenclature. The zone is introduced by Buckman [46]. Detailed discussion and retrospection of the usage of the zone in North-western Europe are given by Dean, Donovan and Howarth [25] and Elmi et al. [45]. In Bulgaria the *Dactylioceras (Orthodactylites) tenuicostatum* Zone is misnamed by Sapunov [14] as "Zone of *Dactylioceras commune* (Sowerby)". Sapunov [49] straightened the name of the zone and it is the first correct use in Bulgarian literature. It appeared that the lower part of "Ferruginized limestones – *Harpoceras serpentinum* Sow. Zone", as used by Nachev and Encheva [15–17] corresponds to the zone [24].

Stratigraphy. This zone corresponds to the range of *Dactylioceras (Orthodactylites)*. The base is drawn by the first appearance in abundance of the subgenus. Usually there is no ammonite record below, and in very few localities in Bulgaria single findings of *Pleuroceras* occur downwards. The top is limited by the incoming of the genera *Harpoceras* and *Hildaites* (Fig. 2). Frequent *Tiltoniceras* and single *Protogrammoceras* are also present. In this way the zone looks to

be comparable to the Tenuicostatum Zone which is in use in North-western Europe [45] (Fig. 2). The main difference lies in relative abundances of *Tiltoniceras* and especially that of *Protogrammoceras* which are more uncommon in Bulgaria.

The best development of the *D. (O.) tenuicostatum* Zone was found from two sections. In the Boukorovtsi Member of the Ozirovo Formation at the town of Teteven the extent of the zone is known to be in 7 m thick succession [24]. In the section at the village of Beledie Han it occupies 30 cm thick bed of ferrug-

Fig. 3. The Dactylioceratidae from the Lower Toarcian in Bulgaria: **a** – ***Dactylioceras (Orthodactylites) crosbeyi*** (Simpson) (M313, coll. L. Metodiev). Dimensions (mm): D = 83.0; H = 20.0 (0.24); E = 18.3 (0.22); O = 48.0 (0.58). Probably wholly septate, from the holostratotype of the Ozirovo Formation at the village of Gorno Ozirovo (W Balkan Mts), *D. (O.) tenuicostatum* Zone, *D. (O.) crosbeyi* Subzone; **b** – ***Dactylioceras (Orthodactylites) tenuicostatum*** (Young & Bird) (BAS J 731, coll. I. Sapunov). Partly extracted specimen (diameter probably assigned up to 65 mm) from the same locality, *D. (O.) tenuicostatum* Zone, *D. (O.) semicelatum* Subzone; **c** – ***Dactylioceras (Orthodactylites) semicelatum*** (Simpson) (M498, coll. L. Metodiev). Dimensions (mm): D = 31.8; H = 9.6 (0.30); E = 7.0 (0.22); O = 15.0 (0.47). Small phragmocone, from the Ozirovo Formation at section 'Kiselchov Dol' (Central Balkan Mts), *D. (O.) tenuicostatum* Zone, *D. (O.) semicelatum* Subzone; **d** – ***Mucrodactyltes*** sp. (M4059, coll. L. Metodiev). Dimensions (mm): D = 29.0; H = 6.7 (0.23); E = 9.7 (0.33); O = 16.7 (0.58). Incomplete phragmocone from the Ozirovo Formation at section near the village of Shipkovo (Central Fore-Balkan), *Harpoceras falciferum* Zone and Subzone; **e** – ***Dactylioceras (Orthodactylites) clevelandicum*** Howarth (M499, coll. L. Metodiev). Dimensions (mm): D = 40.0; H = 10.0 (0.25); O = 20.0 (0.50). Probably wholly septate, from the Ozirovo Formation of section 'Kiselchov Dol', *D. (O.) tenuicostatum* Zone, *D. (O.) crosbeyi* Subzone; **f, g** – ***Dactylioceras (Dactylioceras) temperatum*** (Buckman) (BAS J 730, coll. I. Sapunov). Dimensions (mm): D = 32.0; H = 8.4 (0.26); E = 12.0 (0.38); O = 15.5 (0.48). Incomplete phragmocone from the holostratotype of the Ozirovo Formation, *Hildoceras bifrons* Zone, *Hildoceras lusitanicum* Subzone; **h** – ***Porpoceras vortex*** (Simpson) (M957, coll. L. Metodiev). Strongly flattened adult (diameter about 90 mm), from the Boukorovtsi Member of the Ozirovo Formation at section 'Dobravitsa-2' (W Balkan Mts), *Hildoceras bifrons* Zone, *Hildoceras semipolitum* Subzone; **i, j** – ***Nodicoeloceras crassoides*** (Simpson) – a typical example described and figured by Sapunov (1963, p. 126, pl. 6, figs 1a, b) [23] as "*Catacoeloceras*", from a locality eastwards the village of Makotsevo (Sofia District), *H. bifrons* Zone, *H. lusitanicum* Subzone. Dimensions (mm): D = 73; H = 21.6 (0.30); E = 30.2 (0.42); O = 33.1 (0.46); **k** – ***Zugodactylites braunianus*** (d'Orbigny) (M1918, coll. L. Metodiev). Dimensions (mm): D = 79.0; H = 18.0 (0.23); E = 11.0 (0.14); O = 47.0 (0.59). An adult from the Ozirovo Formation at section 'Kiselchov Dol', *H. bifrons* Zone and Subzone; **l, m** – ***Catacoeloceras crassum*** (Young & Bird) (BAS J 736, coll. I. Sapunov). Dimensions (mm): D = 76.0; H = 22.0 (0.29); E = 26.6 (0.25); O = 38.0 (0.50). An adult from the holostratotype of the Ozirovo Formation, described and figured by Sapunov (1963, p. 125, pl. 5, Figs 3a, b) [23], *H. bifrons* Zone, *H. semipolitum* Subzone; **n** – ***Peronoceras fibulatum*** (J. de C. Sowerby) (BAS J 785, coll. I. Sapunov). Dimensions (mm): D = 63.0; H = 15.2 (0.24); E = 15.1 (0.24); O = 36.0 (0.57). Probably wholly septate, collected from the Ozirovo Formation near the village of Stanyovtsi (Pernik District), described and figured by Sapunov (1963, p. 128, pl. 6, Figs 3a, b) [23], *H. bifrons* Zone and Subzone.
Specimens are figured in reduced size (see dimensions upwards). They are kept in the collections of the University of Sofia, as well as in the Geological Institute of the Bulgarian Academy of Sciences

→


a
b
c
d
e
f
g
h
i
j
k
l
m
n


a
c
d
f
g
b
i
j
e
h
k
m
n
l
o
q
p
r
s
t
u

← Fig. 4. The Hildoceratidae from the Lower Toarcian in Bulgaria: **a, b** – ***Tiltoniceras antiquum*** (Wright) (BAS J 858, coll. I. Sapunov). Dimensions (mm): D = 35.0; H = 17.0 (0.49); E = 10.5 (0.30); O = 7.0 (0.20). An immature from the Ozirovo Formation of section at the village of Shipkovo (Central Fore-Balkan), listed by Sapunov (1968, p. 135) [24] as "*Tiltoniceras schroederi* (Denckmann)", *Dactylioceras (Orthodactylites) tenuicostatum* Zone, *D. (O.) semicelatum* Subzone; **c** – ***Eleganticeras elegantulum*** (Young & Bird) (M4044, coll. L. Metodiev). Dimensions (mm): D = 37.3; H = 18.0 (0.48); E = 8.6 (0.23); H = 9.0 (0.24). Complete immature from the Ozirovo Formation of section at the village of Shipkovo, *Harpoceras falciferum* Zone, *H. serpentinum* Subzone; **d, e** – ***Harpoceras serpentinum*** (Schlotheim) (BAS J 306, coll. I. Sapunov). Dimensions (mm): D = 92.5; H = 44.5 (0.48); E = 18.8 (0.20); O = 21.4 (0.24). Wholly septate from the Ozirovo Formation of section at the village of Shipkovo, listed by Sapunov (1968, p. 135) [24] as "*Harpoceratoides* sp.", *H. falciferum* Zone, *H. serpentinum* Subzone; **f, g** – ***Harpoceras falciferum*** (J. Sowerby) (SU J1101, coll. A. Atanasov). Dimensions (mm): D = 46.5; H = 22.4 (0.48); E = 10.7 (0.23); O = 11.0 (0.24). Wholly septate from the Ozirovo Formation near the village of Beledie Han (W Balkan), *H. falciferum* Zone and Subzone. Original of A. Atanasov (1950, p. 239) [11] misidentified as "*Pseudogrammoceras fallaciosum* Bayle, from red sandy limestones of the Upper Lias". Subsequently figured by Sapunov (1968, pl. 1, Figs 2a, b) [24]; **h** – ***Harpoceras falciferum*** (J. Sowerby) (BAS J 97, coll. I. Sapunov). Dimensions (mm): D = 180.0; H = 85.0 (0.47); E = 35.0 (0.19); O = 38.0 (0.21). Wholly septate from the Boukorovtsi Member of the Ozirovo Formation near the village of Lesidren (Central Fore-Balkan), listed by Sapunov, Tchoumatchenco and Shopov [30] as "*Harpoceras mulgravium* (Young & Bird), *H. falciferum* Zone and Subzone; **i, j** – ***Cleviceras exaratum*** (Young & Bird) (BAS J 677, coll. I. Sapunov). Dimensions (mm): D = 82.3; H = 37.5 (0.46); E = 19.0 (0.23); O = 20.8 (0.25). Wholly septate from the holostratotype of the Ozirovo Formation (W Balkan Mts), *H. falciferum* Zone, *H. serpentinum* Subzone; **k, l** – ***Hildaites murleyi*** (Moxon) (M283, coll. L. Metodiev). Wholly septate (diameter probably assigned up to 100 mm, H = 29.5 mm, E = 27.5 mm), from the holostratotype of the Ozirovo Formation, *H. falciferum* Zone, *H. serpentinum* Subzone; **m, n** – ***Hildaites forte*** (Buckman) (J_1 1194, coll. B. Kamenov). Dimensions (mm): D = 75.0; H = 20.7 (0.28); E = 18.1 (0.24); O = 38.2 (0.51). Probably wholly septate, from an unrecorded locality of the Ozirovo Formation near the village of Balsha (W Balkan Mts), *H. falciferum* Zone; **o, p** – ***Hildoceras laticosta*** Bellini ($J_1$1185, coll. E. Koen). Dimensions (mm): D = 33.0; H = 9.8 (0.30); E = 8.8 (0.27); O = 15.5 (0.47). Incomplete phragmocone, from the Boukorovtsi Member of the Ozirovo Formation in the valley of the river of Koznitsa, south to the town of Teteven, figured by Koen (1932, pl. 2, Fig. 13a) [7] as "*Harpoceras (Hildoceras) levisoni* Simpson", *Hildoceras bifrons* Zone, *Hildoceras lusitanicum* Subzone; **q** – ***Hildoceras lusitanicum*** Meister (J_1 1151, coll. I. Sapunov). Dimensions (mm): D = 35.0; H = 13.0 (0.37); E = 8.0 (0.23); O = 16.0 (0.46). Wholly septate, from the Boukorovtsi Member of the Ozirovo Formation, close to the north of the town of Teteven, listed by Sapunov (1968, p. 137) [24] as "*Hildoceras sublevisoni* Fucini, from the Calcareous-marly horizon with chlorite ooids (No 3)", *H. bifrons* Zone, *H. lusitanicum* Subzone; **r, s** – ***Hildoceras semipolitum*** Buckman (J_1 1181, coll. B. Kamenov). Dimensions (mm): D = 34.4; H = 13.0 (0.38); E = 8.3 (0.24); O = 12.2 (0.35). Incomplete phragmocone, from the Ozirovo Formation near the village of Beledie Han (W Balkan Mts), *H. bifrons* Zone, *H. semipolitum* Subzone; **t, u** – ***Hildoceras bifrons*** (Bruguière) (M010, coll. L. Metodiev). Dimensions (mm): D = 64.1; H = 22.1 (0.34); E = 14.5 (0.23); O = 25.2 (0.39). Wholly septate, from the Boukorovtsi Member of the Ozirovo Formation at section 'Dobravitsa-2' (W Balkan Mts), *H. bifrons* Zone and Subzone.

Specimens are figured in reduced size (see dimensions upwards). They are kept in the collections of the University of Sofia, as well as in the Geological Institute of the Bulgarian Academy of Sciences

inized marls, situated at the base of the Toarcian [38]. In four more sections the *D. (O.) tenuicostatum* Zone is well-defined but much thinner: in the section near the hamlet of Neshkovtsi where it is 15 cm thick [24], in the section near the village of Shipkovo (10 cm), in section 'Kiselchov Dol' (8 cm) and in section 'Golyam Zhidov Dol' (15 cm). Elsewhere, the zone takes part of condensed strata or it is documented by single ammonites that just indicate the presence of *Dactylioceras (Orthodactylites)* association at the bottom of the Toarcian. For instance, the holostratotype of the Ozirovo Formation comprises a highly fossiliferous bed in which characteristic species of *Dactylioceras (Orthodactylites)* occur together with *Harpoceras* and *Hildaites* and many Dactylioceratidae from the *Hildoceras bifrons* Zone [24]. A 90 cm thick bed of ferruginized marls with *Dactylioceras (Orthodactylites)* has been recently found in section 'Dobravitsa-1'. The uppermost 30 cm of this bed hold a big amount of ammonites with two types of preservation: extremely flattened and coarsely ribbed *Dactylioceras (Orthodactylites)*, and phosphatized moulds of *Tiltoniceras*, *Eleganticeras* and finely ribbed *Dactylioceras (Orthodactylites)*. The sections of the Balkan Mts where *Dactylioceras (Orthodactylites)* are less common but sufficient that the *D. (O.) tenuicostatum* Zone to be recognized are that near the village of Milanovo, and the sections at the hut of 'Ambaritsa', on the Dulgi Dyal Ridge and section 'Broussovete' [30]. The zone seems to be also present it two boreholes near the town of Montana.

Two methods of approach for subzonal division of the *D. (O.) tenuicostatum* Zone exist actually in NW Europe. In Yorkshire HOWARTH [47, 50] uses four subzones, from the bottom to the top of the zone: Paltum Subzone which is defined by the distribution of *Protogrammoceras* and the earlier *Tiltoniceras*, Clevelandicum Subzone which corresponds to the combined ranges of *D.*(*O.*) *clevelandicum* Howarth and *D. (O.) crosbeyi* (Simpson), Tenuicostatum Subzone which contains representatives of the index species of the zone, and Semicelatum Subzone which is separated by the occurrences of *D. (O.) semicelatum* (Simpson) and *Tiltoniceras antiquum* (Wright). The Tenuicostatum Zone of the scale as given by Elmi et al. [45] is subdivided into two subzones: Paltus Subzone and Semicelatum Subzone. They believed that the subzones proposed by Howarth are not recognizable outside the United Kingdom both as being based on succession of local development and the absence of some species elsewhere.

It does not seem either Howarth's subzonal set or subzones employed by Elmi et al. can be used in Bulgaria. The *Protogrammoceras* were collected in very low number. Besides, *Tiltoniceras* were found to be represented in the upper part of the zone. The evidence from Bulgarian localities displayed a distribution of *Dactylioceras (Orthodactylites)* which is initiated by coarsely ornamented, more involute and more depressed species – *D. (O.) crosbeyi* (Simpson) and *D. (O.) clevelandicum* Howarth. They are followed upwards by more evolute and more finely ribbed species of more compressed conch – *D. (O.) tenuicostatum* (Young & Bird) and *D. (O.) semicelatum* (Simpson). A subdivision of the *D. (O.) tenuicostatum* Zone into a lower *D. (O.) crosbeyi* Subzone and upper *D.*

(O.) semicelatum Subzone is therefore preferred in this study.

Dactylioceras (Orthodactylites) crosbeyi Subzone

INDEX SPECIES. *Dactylioceras (Orthodactylites) crosbeyi* (Simpson, 1843). The holotype was figured by Buckman (1920, pl. 60) [48]. According to Howarth (1973, p. 255) [47] it is from "bed 18 of the Grey Shales" near Whitby (Yorkshire, England) and it is kept in Whitby Museum (No WM134).

The species has been recorded for the first time in Bulgaria in the condensed Lower Toarcian of the holostratotype of the Ozirovo Formation at the village of Gorno Ozirovo [24]. One specimen from the same locality is figured here (Fig. 3a).

NOMENCLATURE. The subzone was initially nominated by METODIEV [39] to denote the lower part of the total range of *Dactylioceras (Orthodactylites)* in Bulgaria. In this manner it is adopted to be an equivalent of the Paltus Subzone and the Crosbeyi Horizon of the Semicelatum Subzone as used by Elmi et al. [45] (Fig. 2). In this study the subzone is incorporated into the Bulgarian ammonite zonal standard.

STRATIGRAPHY. The subzone is defined by the combined ranges of *D. (O.) crosbeyi* (Simpson) and *D. (O.) clevelandicum* Howarth (Fig. 3e) which are accompanied somewhere by rare *Protogrammoceras* at the very base. It has been recognized on occurrences of the defining species in several sections. In the section at the village of Beledie Han the subzone comprises the lower half of the *D. (O.) tenuicostatum* Zone. In section 'Dobravitsa-1' it is separated by the presence of the above-mentioned flattened specimens of *Dactylioceras (Orthodactylites)* among which *D. (O.) crosbeyi* seems to be the most frequent. The section 'Kiselchov Dol' contains two ammonite-bearing beds with *Dactylioceras (Orthodactylites)*,

Fig. 5. The Dactylioceratidae, Phymatoceratidae and Grammoceratinae from the Toarcian in Bulgaria: **a** – ***Haugia evoluta*** Gabilly (M1940, coll. L. Metodiev). Dimensions (mm): D = 71.0; H = 25.0 (0.35); E = 15.0 (0.21); O = 32.0 (0.45). Wholly septate, from the Ozirovo Formation at section 'Kiselchov Dol' (Central Balkan), *base of Haugia variabilis* Zone; **b** – ***Brodieia*** sp. (M275, coll. L. Metodiev). Dimensions (mm): D = 29.0; H = 10.7 (0.37); E = 8.5 (0.29); O = 9.7 (0.33). Probably wholly septate, from the Boukorovtsi Member of the Ozirovo Formation at section 'Dobravitsa-1' (W Balkan Mts), *H. variabilis* Zone; **c, d** – ***Denckmannia fabalis*** (Simpson) (M026, coll. L. Metodiev). Dimensions (mm): D = 45.0; H = 15.4 (0.34); E = 13.1 (0.29); O = 19.0 (0.44). Part of the phragmocone preserved, from the Boukorovtsi Member of the Ozirovo Formation at section 'Dobravitsa-2' (W Balkan Mts), *H. variabilis* Zone, *Denckmannia* spp. Subzone; **e, f** – ***Collina gemma*** Bonarelli (M1115, coll. L. Metodiev). Dimensions (mm): D = 25.5; H = 7.0 (0.27); E = 6.7 (0.26); O = 14.3 (0.56). Inner whorls of bigger specimen collected from the Boukorovtsi Member of the Ozirovo Formation at section 'Dobravitsa-2', *H. variabilis* Zone, *Collina* spp. Subzone; **g** – ***Collina*** sp. (M1081, coll. L. Metodiev). Dimensions (mm): D = 40.5; H = 9.0 (0.22); E = 12.0 (0.30); O = 23.0 (0.57). Wholly septate, from the same locality, *H. variabilis* Zone, *Collina* spp. Subzone; **h** – ***Denckmannia malagma*** (Dumortier) (M3009, coll. L. Metodiev). Probably wholly septate (diameter assigned up to 90 mm), from the same locality, *H. variabilis* Zone, *Denckmannia* spp. Subzone; **i, j** – ***"Chartronia"*** sp. (M643, coll. L. Metodiev). Dimensions (mm): D = 92.0; H = 30.5 (0.33); E = 13.0 (0.14); O = 40.5 (0.44). An adult with the beginning of the body chamber preserved, from the Ozirovo Formation of section 'Kiselchov Dol', →

H. variabilis Zone, *Denckmannia* spp. Subzone; **k** – ***Phymatoceras cornucopia*** (Merla) (J_1 1175, coll. I. Sapunov). Dimensions (mm): D = 49.0; H = 19.0 (0.35); O = 21.5 (0.42). Probably wholly septate, from the holostratotype of the Ozirovo Formation, *H. bifrons* Zone; **l, m** – ***Podagrosites aratum*** (Buckman) ($J_1$93, coll. I. Sapunov). Dimensions (mm): D = 58.0; H = 20.5 (0.35); E = 15.0 (0.26); O = 25.0 (0.43). Wholly septate, from the Boukorovtsi Member of the Ozirovo Formation south-east of the village of Gintsi (W Balkan Mts), described and figured by Sapunov and Nachev (1959, p. 53, pl. 3, Figs 1, 2) [18] as "*Catulloceras aratum* Buckman", reexamined by Metodiev (2002, p. 178, pl. 1, Fig. 14) [33], base of the *Grammoceras thouarsense* Zone; **n, o** – ***Pseudogrammoceras muelleri*** (Denckmann) ($J_1$1164, coll. S. Juranov). Dimensions (mm): D = 47.7; H = 18.4 (0.39); E = 10.8 (0.23); O = 17.2 (0.36). Wholly septate, from the Boukorovtsi Member of the Ozirovo Formation to the east of the village of Gintsi, described and figured by Metodiev (2002, p. 181, pl. 3, Fig. 8) [33], indicating *Pseudogrammoceras bingmanni* Subzone of the *G. thouarsense* Zone; **p** – ***Podagrosites pseudogrunowi*** Guex (M197, coll. L. Metodiev). Part of the phragmocone preserved (H = 10.0 mm, E = 9.5 mm), from the Boukorovtsi Member of the Ozirovo Formation at section 'Dobravitsa-1' (W Balkan Mts), *G. thouarsense* Zone; **q** – ***Podagrosites latescens*** (Simpson) (M044, coll. L. Metodiev). Dimensions (mm): D = 39.8; H = 14.4 (0.26); E = 12.3 (0.31); O = 12.0 (0.30). Wholly septate, from the same locality (*G. thouarsense* Zone), described and figured by Metodiev (1997, p. 19, pl. 4, Fig. 1) [32] as "*Pseudogrammoceras latescens*"; **r, s** – ***Polyplectus discoides*** (Zieten) (SU J 01095, coll. M. Encheva). Dimensions (mm): D = 38.3; H = 21.2 (0.55); E = 18.0 (0.21); O = 4.3 (0.11). Wholly septate, from the Ozirovo Formation of the section at the hamlet of Neshkovtsi (Central Balkan), figured by Encheva (1960, p. 106, pl. 3, Fig. 2) [17], *Pseudogrammoceras fallaciosum* Zone; **t** – ***Grammoceras thouarsense*** (d'Orbigny) (M012, coll. L. Metodiev). Dimensions (mm): D = 118.0; H = 31.0 (0.26); E = 20.5 (0.17); O = 51.0 (0.43). An adult from the Boukorovtsi Member of the Ozirovo Formation at section 'Dobravitsa-1' (*G. thouarsense* Zone), figured by Metodiev (1997, pl. 3, Fig. 3) [32]; **u** – ***Pseudogrammoceras struckmanni*** (Denckmann) ($J_1$1147, coll. S. Kerekov). Dimensions (mm): D = 71.0; H = 25.0 (0.35); E = 14.0 (0.20); O = 33.0 (0.46). Part of an adult, from the Ozirovo Formation of a locality near the hamlet of Neshkovtsi, listed by Kerekov (1951, p. 75) [13] as "*Grammoceras radians* (Reinecke)", reexamined by Metodiev (2002, p. 180, pl. 3, Fig. 3) [33], *G. thouarsense* Zone, *Pseudogrammoceras bingmanni* Subzone; **v** – ***Pseudogrammoceras pachu*** Buckman ($J_1$1147, coll. I. Sapunov). Dimensions (mm): D = 111.2; H = 33.5 (0.30); E = 21.3 (0.19); O = 44.2 (0.40). An adult, from the Ozirovo Formation of the section at the hamlet of Neshkovtsi, listed at first by Sapunov (1968, p. 147) [24], subsequently reexamined by Metodiev (2002, p. 179, pl. 2, Fig. 2) [33], *G. thouarsense* Zone and Subzone; **w-** ***Esericeras fascigerum*** (Buckman) ($J_1$1153, coll. I. Sapunov).). Dimensions (mm): D = 62.0; H = 27.0 (0.44); E = 10.0 (0.16); O = 19.0 (0.31). Wholly septate, from the Ozirovo Formation of section at the village of Beledie Han (W Balkan), *G. thouarsense* Zone, *E. fascigerum* Subzone; **x, y** – ***Pseudogrammoceras bingmanni*** (Denckmann) ($J_1$85, coll. I. Sapunov). Dimensions (mm): D = 94.8; H = 34.5 (0.36); E = 19.0 (0.20); O = 35.7 (0.38). Probably wholly septate, from the Boukorovtsi Member of the Ozirovo Formation east of the village of Gintsi, described and figured by Metodiev (2002, p. 181, pl. 3, Fig. 5) [33], *G. thouarsense* Zone, *P. bingmanni* Subzone; **z** – ***Pseudogrammoceras fallaciosum*** (Bayle) ($J_1$1152, coll. I. Sapunov). Dimensions (mm): D = 75.7; H = 29.0 (0.38); E = 14.7 (0.19); O = 25.0 (0.33). Wholly septate example of the morphotype "*cotteswoldiae*", from the Ozirovo Formation of the section at the hamlet of Neshkovtsi, listed by Sapunov (1968, p. 147) [24], reexamined by Metodiev (2002, p. 183, pl. 5, Fig. 3) [33], *Pseudogrammoceras fallaciosum* Zone.

Specimens are figured in reduced size (see dimensions upwards). They are kept in the collections of the University of Sofia, as well as in the Geological Institute of the Bulgarian Academy of Sciences →


a
b
c
d
e
f
g
h
i
j
k
l
m
n
o
p
q
r
s
t
u
v
w
x
y
z


a
b
c
d
e
f
g
h
i
j
k
l
m
n
o
p
q
r
s
M139
t
u
v
w
x
y
z

Fig. 6. The Grammoceratinae and Hammatoceratinae from the Upper Toarcian in Bulgaria: **a** – ***Phlyseogrammoceras dispansum*** (Lycett) (M648, coll. L. Metodiev). Partly extracted small specimen (diameter about 45 mm), from the Ozirovo Formation at section to the north of the village of Dragovishtitsa (W Balkan), *P. dispansum* Zone; **b** – ***Phlyseogrammoceras maubeugei*** Metodiev & Sapunov (BAS J 263, coll. I. Sapunov). Dimensions (mm): D = 27.9; H = 11.9 (0.43); E = 6.4 (0.23); O = 8.1 (0.29). The holotype, from the Ozirovo Formation of the same section, described and figured by Metodiev and Sapunov (1999, p. 48, pl. 1, Fig. 5) [37], *P. dispansum* Zone; **c** – ***Pseudolillia emiliana*** (Reynès) (coll. M. Encheva). Dimensions (mm): D = 28.0; H = 10.6 (0.39); E = 7.0 (0.25); O = 10.7 (0.38). An immature from the Ozirovo Formation, probably from *Pseudogrammoceras fallaciosum* Zone, section at the hamlet of Neshkovtsi (Central Balkan); **d, e** – ***Pseudolillia emiliana*** (Reynès) (BAS J 907, coll. I. Sapunov). Dimensions (mm): D = 30.0; H = 12.0 (0.40); E = 6.2 (0.21); O = 10.2 (0.34). Wholly septate, from the same section, *P. fallaciosum* Zone; **f** – ***Hammatoceras speciosum*** Janensch (M4160, coll. L. Metodiev). Dimensions (mm): D = 59.0: H = 27.0 (0.45); O = 16.7 (0.28). Probably wholly septate, from the Boukorovtsi Member of the Ozirovo Formation at section 'Dobravitsa-1' (W Balkan), *P. dispansum* Zone; **g** – ***Phlyseogrammoceras beneckei*** Maubeuge (M649, coll. L. Metodiev). Dimensions (mm): D = 52.0; H = 21.0 (0.40); E = 9.0 (0.17); E = 16.8 (0.32). Probably wholly septate with the beginning of the body chamber preserved, from the Ozirovo Formation at section near the village of Dragovishtitsa, *P. dispansum* Zone; **h** – ***Dumortieria levesquei*** (d'Orbigny) (BAS J 290, coll. I. Sapunov). Dimensions (mm): D = 71.6; H = 23.0 (0.32); O = 33.0 (0.46). Wholly septate, from the same section, *Dumortieria pseudoradiosa* Zone, *D. levesquei* Subzone; **i** – ***Dumortieria prisca*** Buckman (M624, coll. L. Metodiev). Dimensions (mm): D = 20.0; H = 6.0 (0.30); E = 6.0 (0.30); O = 10.6 (0.53). An immature, from the Ozirovo Formation of the same section, *D. pseudoradiosa* Zone, *D. levesquei* Subzone; **j** – ***Dumortieria insignisimilis*** (Brauns) (M4193, coll. L. Metodiev). Dimensions (mm): D = 52.0; H = 16.0 (0.31); E = 16.5 (0.32); O = 25.0 (0.48). Probably wholly septate, from the Ozirovo Formation at section 'Golyam Zhidov Dol' (Central Balkan), *D. pseudoradiosa* Zone, *D. levesquei* Subzone; **k** – ***Dumortieria pannonica*** Géczy (BAS J 263, coll. I. Sapunov). Dimensions (mm): D = 65.6; H = 19.4 (0.30); E = 15.4 (0.23); O = 33.0 (0.50). Probably wholly septate, from the Ozirovo Formation at section near the village of Dragovishtitsa, *D. pseudoradiosa* Zone, *D. levesquei* Subzone; **l** – ***Dumortieria multicostata*** Buckman (BAS J 149, coll. I. Sapunov). Dimensions (mm): D = 36.8; H = 13.4 (0.36); E = 10.7 (0.29); O = 13.4 (0.36). Incomplete specimen, from the Ozirovo Formation, south to the hut of 'Ambaritsa' (Central Balkan), *D. pseudoradiosa* Zone and Subzone; **m** – ***Dumortieria rhodanica*** Haug (F.003200, coll. L. Metodiev). Deformed specimen (diameter about 30 mm, H = 11.0 mm, E = 12 mm), from the Ozirovo Formation at section 'Golyam Zhidov Dol', *D. pseudoradiosa* Zone and Subzone; **n** – ***Dumortieria pseudoradiosa*** (Branco) (M4002, coll. L. Metodiev). Dimensions (mm): at D = 70.0; H = 22.0 (0.31); E = 13.0 (0.19); O = 29.0 (0.41). An adult with flattened beginning of the body chamber, from the Ozirovo Formation at section 'Kiselchov Dol' (Central Balkan), *D. pseudoradiosa* Zone and Subzone; **o** – ***Dumortieria regularis*** Buckman (M879, coll. L. Metodiev). Dimensions (mm): D = 80.5; H = 25.0 (0.31); E = 14.0 (0.17); O = 39.7 (0.49). Complete adult with preserved mouth-border, from the Boukorovtsi Member of the Ozirovo Formation, section 'Dobravitsa-1', *D. pseudoradiosa* Zone and Subzone; **p** – ***Dumortieria explanata*** Buckman (F.003202, coll. L. Metodiev). Dimensions (mm): D = 23.0; H = 8.6 (0.37); E = 7.7 (0.33); O = 10.3 (0.45). Incomplete specimen, from the Ozirovo Formation at section 'Golyam Zhidov Dol', *D. pseudoradiosa* Zone and Subzone; **q** – ***Pleydellia aalensis*** (Zieten) (M025, coll. L. Metodiev). Dimensions (mm): D = 35.2; H = 14.4 (0.41); E = 7.3 (0.21); O = 11.7 (0.33). An immature with partly preserved ← body chamber, from the Boukorovtsi Member of the Ozirovo Formation, section 'Dobra-

vitsa-1', described and figured by Metodiev (1997, p. 23, pl. 4, Fig. 5) [32], *P. aalensis* Zone and Subzone; **r** – ***Pleydellia subcompta*** (Branco) (M033, coll. L. Metodiev). Dimensions (mm): D = 47.7; H = 20.8 (0.44); E = 7.6 (0.16); O = 14.2 (0.30). Almost complete with body chamber that covers a half of the last whorl, from the same section, described and figured by Metodiev (1997, p. 22, pl. 4, Fig. 6) [32], *P. aalensis* Zone and Subzone; **s** – ***Pleydellia (Cotteswoldia) egena*** Buckman (M139, coll. L. Metodiev). Dimensions (mm): D = 32.0; H = 12.6 (0.39); O = 13.8 (0.43). Probably wholly septate with the very beginning of the body chamber preserved, from the same section, *P. aalensis* Zone, *P. mactra* Subzone; **t** – ***Pleydellia mactra*** (Dumortier) (coll. L. Metodiev). A negative of small specimen (diameter about 30 mm), from the Ozirovo Formation, section at the village of Beledie Han (W Balkan Mts), *P. aalensis* Zone, *P. mactra* Subzone; **u** – ***Pleydellia (Cotteswoldia)*** aff. ***attrita*** Buckman (M3040, coll. L. Metodiev). Dimensions (mm): at D = 38.0; H = 16.0 (0.42); E = 6.0 (0.16); O = 13.7 (0.26). Inner whorls of bigger specimen with the beginning of the body chamber, from the Ozirovo Formation at section 'Kiselchov Dol', *P. aalensis* Zone, *P. mactra* Subzone; **v** – ***Pleydellia (Walkericeras)*** aff. ***lugdunensis*** Elmi & Rulleau (M3098, coll. L. Metodiev). Dimensions (mm): at D = 50.0; H = 22.0 (0.44); O = 18.0 (0.36). Part of inner whorls and the body chamber, from the Ozirovo Formation at section 'Kiselchov Dol', *P. aalensis* Zone and Subzone; **w** – ***Pleydellia leura*** Buckman (M4030, coll. L. Metodiev). Dimensions (mm): D = 54.6; H = 20.5 (0.38); E = 8.6 (0.16); O = 18.8 (0.34). Wholly septate, from the same section, *P. aalensis* Zone and Subzone; **x** – ***Pleydellia (Cotteswoldia) paucicostata*** Buckman (M3097, coll. L. Metodiev). Dimensions (mm): D = 50.0; H = 18.5 (0.37); E = 7.0 (0.14); O = 17.8 (0.36). Complete specimen with body chamber that covers the outer half of the last whorl, from the same section, *P. aalensis* Zone and Subzone; **y** – ***Pleydellia buckmani*** Maubeuge (M3040, coll. L. Metodiev). Dimensions (mm): D = 25.0; H = 10.0 (0.40); E = 5.8 (0.23); O = 8.3 (0.33). Incomplete specimen, from the Ozirovo Formation of the same section, top of *P. aalensis* Zone and Subzone; **z** – ***Pleydellia (Cotteswoldia) bifax*** Buckman (BAS J 721, coll. I. Sapunov). Dimensions (mm): at D = 55.0; H = 21.0 (0.38); E = 9.0 (0.16); O = 11.8 (0.37). Probably wholly septate, from the Ozirovo Formation of section at the hamlet of Neshkovtsi , *P. aalensis* Zone, *P. mactra* Subzone.

Specimens are figured in reduced size (see dimensions upwards). They are kept in the collections of the University of Sofia, as well as in the Geological Institute of the Bulgarian ← *Academy of Sciences*

each of them 4 cm thick, and the lower-one is full of *D. (O.) crosbeyi* and single *Protogrammoceras*. The *D. (O.) crosbeyi* Subzone is also discernible in section 'Golyam Zhidov Dol' where the fossils upon it was founded are separated only at the bottom of a bed that preserves the *Dactylioceras (Orthodactylites)* association. The records of the sections at the village of Shipkovo and near the hamlet of Neshkovtsi are too thin and too mixed that cause the subzone to be unrecognizable. In the rest of the exposures which are known to contain representatives of subgenus *Orthodactylites*, the ammonites have yet to be collected in detail.

Dactylioceras (Orthodactylites) semicelatum Subzone

Index species. *Dactylioceras (Orthodactylites) semicelatum* (Simpson, 1843). The holotype was figured by Buckman (1911, pl. 31) [48]. According to Howarth (1973, p. 262) [47] it comes from "bed 28 or 30 of the Grey Shales", near Whitby (Yorkshire, England) and it is kept in Whitby Museum (No WM116).

The first record of the species in Bulgaria is again from the condensed Lower Toarcian of the holostratotype of the Ozirovo Formation at the village of Gorno Ozirovo [24]. A small phragmocone from the Ozirovo Formation of section 'Kiselchov Dol' is shown herein (Fig. 3c).

NOMENCLATURE. According to Elmi et al. [45] this name was first used by Mouterde in 1967 in order to define the *Dactylioceras (Orthodactylites)* succession in Portugal as a proper zone, because of the rarity of *D. (O.) tenuicostatum* into the zonal assemblage. In meaning of subzone it was used firstly by Howarth in Yorkshire [47]. In this paper, the *D. (O.) semicelatum* Subzone has a bigger extent than that adopted by Howarth and less expanded range as used by Elmi et al. [45] (Fig. 2). It was initially nominated by Metodiev [39], but in this study the subzone come into use in Bulgaria.

STRATIGRAPHY. The subzone is defined by the distribution of *D. (O.) tenuicostatum* (Young & Bird) and *D. (O.) semicelatum* (Simpson). *Tiltoniceras antiquum* (Wright) also occur and one of them is figured here (Fig. 4a, b). In addition to the previously listed exposures that produced a possibility for subzonal separation, it is necessary to subjoin that near the town of Teteven where the characteristic species of *D. (O.) semicelatum* Subzone are very common in the upper 4 metres of the total extent of the zone.

***Harpoceras falciferum* Zone**

INDEX SPECIES. *Harpoceras falciferum* (J. Sowerby, 1820). The holotype was figured by SOWERBY (1820, pl. 245, fig. 2) [51], and comes from "layer M, Junction Bed, Thorncombe Beacon" (Dorset, England) as documented by Howarth [50]. It has been refigured several times, e. g. Buckman (1928, pl. 764) [48], Dean, Donovan and Howarth (1961, pl. 72, Fig. 3) [25], and more recently by Howarth (1992, pl. 19, Fig. 2) [50]. It is kept into the collections of the Natural History Museum London (No BM 43496) [50].

The index species of the zone is very common in Bulgaria. The richest locality is that of the highly condensed bed of the holostratotype of the Ozirovo Formation at the village of Gorno Ozirovo [24]. Three Bulgarian specimens have been previously figured: a badly preserved incomplete specimen, from the Boukorovtsi Member of the Ozirovo Formation close to the north of the town of Teteven (Sapunov, 1959, pl. 4, Figs 7, 8) [14], a wholly septate from the Ozirovo Formation near the village of Beledie Han which was misidentified as "*Pseudogrammoceras fallaciosum* Bayle" [11], figured by Sapunov (1968, pl. 1, Figs 1a-c) [24] and refigured herein (Fig. 4f, g), and photographically reduced fragment of an adult, form the Boukorovtsi Member of the Ozirovo Formation of section 'Dobravitsa-1' (Metodiev, 1997, pl. 1, Fig. 8) [32]. One big wholly septate example from the Boukorovtsi Member of the Ozirovo Formation at the town of Teteven is figured in this paper (Fig. 3h).

NOMENCLATURE. The history of recognition of this zone has been done by Dean, Donovan and Howarth [25] to be a little bit complicated. At the beginning

of the Jurassic ammonite zoning, whole the Lower Toarcian has been referred to a zone with index nominated on bivalve species – "*Posidonia bronni*", although Oppel himself suggested that *Ammonites serpentinus* Reinecke is better to be used as a zonal index [5]. The first division of Oppel's Bronni Zone by Reynès [52] was two-fold: Bifrons Zone (above) and Serpentinus Zone (below). The subsequent recognition of *D. (O.) tenuicostatum* Zone reduced the extent of Serpentinus Zone from below. Haug [53] have had well-founded doubts that most of the records of *Harpoceras serpentinum* in literature from this time are misidentifications of *Harpoceras falciferum*. That led to the nomination of *H. falciferum* as the index species of the zone instead of *H. serpentinum*, and now Haug is considered to be the original author of the *Harpoceras falciferum* Zone. Elmi et al. [45] reverted to *H. serpentinum* in their zonal scale for reasons of priority on account of Oppel's informal opinion.

In Bulgaria the *Harpoceras falciferum* Zone is used for the first time by Sapunov [14] as "Zone of *Harpoceras falcifer* (Sowerby)". The upper part of "Ferruginized limestones – *Harpoceras serpentinum* Sow. Zone" of Nachev and Encheva [15–17] was found to be corresponding to the *H. falciferum* Zone [24].

Stratigraphy. The zone is defined in Bulgaria by the combined ranges of *Harpoceras* and *Hildaites* (Fig. 2). Former genus was recently found to come out upwards outside the zone and to occur together with ammonites which are characteristic for the lower and the middle part of the *Hildoceras bifrons* Zone. However, it seems that the relative distribution of *Harpoceras* upwards is of a lower amount than into its own zone. The mass-presence of the genus in the ammonite successions of the *H. falciferum* Zone and respectively the decreasing in number of the specimens that occur higher up are considered as good criteria for distinction of the zone of the sections studied. The genus *Hildaites* displays a distribution which coincides with the lower part of the total-range of *Harpoceras*, in conjunction with the earliest species of *Harpoceras* lineage – *H. serpentinum* (Schlotheim). The advent of the index species of the *H. falciferum* Zone follows that of *H. serpentinum* and it seems that they are in descendant-ancestral relationship [50]. In Bulgaria the appearance of *H. falciferum* has been found to be coincident with the incoming of the earliest representatives of *Hildoceras*, as well as with the first appearance of *Orthildaites* and several later members of the family Dactylioceratidae such as *Nodicoeloceras*, *Catacoeloceras*, *Mucrodactylites* and *Dactylioceras (Dactylioceras)*. These events were accepted as reasonable evidence that *H. falciferum* Zone to be separated in two: *H. serpentinum* and *H. falciferum* Subzones [39].

The preference for usage of *H. serpentinum* as a subzonal index species instead of *Eleganticeras elegantulum* (Young & Bird) as it is used in NW Europe by Elmi et al. [45] has been given to the scattered record of the genus *Eleganticeras* in Bulgaria. Its presence into the association of the *H. falciferum* Zone has already been assumed by Sapunov [24]. Indeed, the genus is represented and that

has been recently dated, but only in few specimens. Other genera that appear to be less common in Bulgaria than in the North-western Europe are *Cleviceras* and *Ovaticeras*. Former has become recognizable quite lately in small number of ammonites. Later has been found in only one specimen [24]. Nevertheless, the *H. falciferum* Zone as used herein and the proposed subzones can be correlated exactly with those of the scale of Elmi et al. [45] (Fig. 2).

The *H. falciferum* Zone is well-developed almost throughout the Balkan Mts Area. Unfortunately the richest locality of the zonal association is that of the holostratotype of the Ozirovo Formation where the zone is condensed [24]. The observed high morphological variability of the genus *Harpoceras* which has been found in the specimens collected from this site and which is well-known from many localities in NW Europe [50] could not be estimated from taxonomic and biostratigraphical point of view. The best exposure that represents the zone is that of the section near the village of Shipkovo. It contains a highly fossiliferous bed (30 cm thick) which was a supporting point of the recognition of the subzones in Bulgaria. The *H. falciferum* Zone is also well-dated in terms of its subzones in the section at the village of Beledie Han [38], in the section near the hamlet of Neshkovtsi where it is 45 cm thick [24], and in section 'Kiselchov Dol' (30 cm thickness in two beds with beautifully preserved *Harpoceras* and allied genera). It has been estimated to be from 3 to 5 m thick in two localities of the Boukorovtsi Member of the Ozirovo Formation to the west and the north-west of the town of Teteven by Sapunov, Tchoumatchenco and Shopov [27] but the evidence seems to be too scarce to accept that. The zone has been recently found in section 'Dobravitsa-1' as being partly mixed in its base together with the ammonites from the top of the *D. (O.) tenuicostatum* Zone. In the other localities from the Balkan Mts the record of the *H. falciferum* Zone is incomplete. It has been established by few ammonites in section 'Dobravitsa-2' [32], in the section at the town of Teteven [27], in the section near the village of Milanovo, in section 'Golyam Zhidov Dol', and to the south of the hut of 'Ambaritsa" [30]. Single ammonites have been obtained from the exposures near the village of Dragovishtitsa, on the Dulgi Dyal Ridge and the section 'Broussovete' [30], as well as from one borehole near the town of Montana.

Harpoceras serpentinum Subzone

Index species. *Harpoceras serpentinum* (Schlotheim, 1813). The lectotype was designated by Howarth (1992, p. 109) [50]. According to the same author, it is the only remaining syntype in Schlotheim Collection which is kept into the Museum of Geology and Palaeontology of the Berlin University (No Qu.Kat.6.2.p.309). This is a fragment of a large specimen collected near the town of Nürnberg (SW Germany) and it was figured by Howarth (1992, Text-fig. 23, p. 110) [50].

In Bulgaria the index species of the subzone has always been determined as *Harpoceratoides alternatus* (Simpson) so far [24, 29, 30]. Here is followed Howarth's opinion [50] that the generic name *Harpoceratoides* has been proposed by Buckman

[48] on a specimen called *Ammonites alternatus* by Simpson in 1843 which is an example of *Harpoceras serpentinum*. Thereby *Harpoceratoides* is a synonym of *Harpoceras*, and *H. alternatus* is a synonym of *H. serpentinum*. The ammonites of *H. serpentinum* have never been figured in Bulgaria before. In this paper, an example from the Ozirovo Formation of section at the village of Shipkovo is shown (Fig. 4d, e).

Nomenclature. The name was first used by Metodiev [39] in meaning of a subzonal unit in order to separate the ammonite record from the lower part of the *Harpoceras falciferum* Zone in Bulgaria. In this sense, the subzone corresponds to the Elegantulum Subzone as defined by Elmi et al. [45] (Fig. 2) and to the Exaratum Subzone sensu Dean, Donovan and Howarth [25] and Howarth [50]. The arguments for employment of *H. serpentinum* instead *Eleganticeras elegantulum* or *Cleviceras exaratum* as in French or British scales are given above at the description of the zone.

Stratigraphy. The subzone corresponds to the combined ranges of *Harpoceras serpentinum* and *Hildaites*. It is documented by the abundance of ammonites of the index species which are usually attended by large numbers of three species of the genus *Hildaites*. Later is represented mostly by specimens of *H. murleyi* (Moxon) and *H. forte* (Buckman) some of them attaining giant sizes. Two good examples of these species are shown here (Fig. 4k–n). Another species of *Hildaites* which has been found in Bulgaria is *H. subserpentinus* Buckman but it seems to be more occasional. Two more genera occur into the *H. serpentinum* Subzone – *Eleganticeras* and *Cleviceras* (Fig. 2), but as mentioned above they are very uncommon. One ammonite from each of them is figured in this paper: *Eleganticeras elegantulum* (Young & Bird) (Fig. 4c) and *Cleviceras exaratum* (Young & Bird) (Fig. 4i, j). The examples of *C. exaratum* have been referred to *Harpoceras* before and thought to be coeval with *H. falciferum* [24, 29]. The new evidence from newly collected material displayed an incoming of *Cleviceras* which is prior to that of *Harpoceras falciferum*.

Harpoceras falciferum Subzone

Index species and Nomenclature. See *H. falciferum* Zone. The subzone was initially nominated by Metodiev [39] to be the upper subzone of the *H. falciferum* Zone in Bulgaria. It is incorporated into the Bulgarian ammonite zonal standard in this study. The subzone is considered to be a correlate with the Falciferum Subzone as used by Elmi et al. [45] (Fig.2).

Stratigraphy. The lower limit is drawn at the appearance of the index that coincides with the advent of *Dactylioceras (Dactylioceras)*, *Catacoeloceras*, *Nodicoeloceras*, *Orthildaites*, *Mucrodactyltes* and first *Hildoceras*. The top is limited by the mass-incoming of *Hildoceras*. *Ovaticeras* has been recorded solely by one specimen [24, 29]. The emergence of *D. (Dactylioceras)*, *Nodicoeloceras* and *Catacoeloceras* into this assemblage has been previously documented by Sapunov [24], by examples of *D. (D.) crassiusculosum* (Simpson), *Catacoeloceras fonticulum*

(Simpson) and *Nodicoeloceras crassoides* (Simpson). However, the earliest record of *Nodicoeloceras* and *Dactylioceras (Dactylioceras)* in Bulgaria has been found to be that of *N. spicatum* Buckman and *D. (D.) annulatum* Buckman. The new elements of the association are those of *Orthildaites* and *Mucrodactyltes*. Former has been collected at first in the section at the village of Beledie Han [38] and its presence has been proven consequently in three more exposures: in the section near the town of Teteven, in section 'Kiselchov Dol' and section 'Golyam Zhidov Dol' as well. *Mucrodactyltes* has been considered to be better represented upwards into the *Hildoceras bifrons* Zone [34], but suddenly few specimens of undoubted affiliation to the *H. falciferum* Subzone were collected from the section at the village of Shipkovo, and one of them is figured here (Fig. 3d). The overlap between the ranges of *Harpoceras* and *Hildoceras* was not known in Bulgaria so far. There is no doubt now that *Hildoceras laticosta* Bellini and *Hildoceras lusitanicum* Meister appear along with *Harpoceras falciferum* and it was demonstrated from the record of the section at the village of Beledie Han [38]. Concerning *H. falciferum*, it is necessary to note that its occurrence has been extended upwards beyond its nominal subzone. Many specimens have come from beds which are clearly associated with the *H. bifrons* Zone. Moreover, the original stratigraphic occurrence of two more *Harpoceras* species – *H. subplanatum* (Oppel) and *H. soloniasense* (Lissajous) (later newly recorded in Bulgaria), has been dated to be also into the *H. bifrons* Zone. It was not surprising because such evidence already exists a long time ago from outside the country.

***Hildoceras bifrons* Zone**

Index species. *Hildoceras bifrons* (Bruguière, 1789). The holotype was one of the earliest figured species of ammonites and that happened more than three centuries ago. A reproduction of Lister's figure from 1678 and the original description of Bruguière have been given by Buckman (1918a, pl. 114b, c), followed by the picture of the holotype (Buckman, 1918a, pl. 114A) [48] have made the original specimen to be widely known. Afterwards the holotype was frequently refigured, e.g. by Dean, Donovan and Howarth (1961, pl. 72, Fig. 4) [25] and Howarth (1992, pl. 37, Fig. 1) [50]. It is from the Alum Shales (Bifrons Zone) at Whitby (Yorkshire, England), and it takes a part of the Natural History Museum, London collection (BM C.55848).

In Bulgaria the index species is very common. It has been described and figured several times, by Toula (1881, pl. 1, Fig. 8a, b) [1], Koen (1932, p. 19, pl. 2, Fig. 12a, b) [7], Kerekov (1953, p. 75) [14], Sapunov and Nachev (1959, p. 55, pl. 3, Figs 7, 8) [18], Encheva (1960, pl. 3, Fig. 5) [17], Sapunov (1968, pl. 2, Fig. 1) [24] and Metodiev (1997, p. 16, pl. 2, Fig. 3) [32]. In this study one wholly septate specimen from the Boukorovtsi Member of the Ozirovo Formation at section 'Dobravitsa-2' is shown (Fig. 4t, u).

Nomenclature. According to Dean, Donovan and Howarth [25] *Hildoceras bifrons* was first used as index-fossil by Eudes-Deslongchamps in 1864 in Nor-

mandy and it was nominated on succession which is known to be corresponding to the modern *H. falciferum* and *H. bifrons* Zones. Reynès [52] subsequently separated "Zone à *Ammonites bifrons*" between the "Zone à *Ammonites jurense*" (above) and the "Zone à *Ammonites serpentinus*" (below). Detailed discussion and retrospection of the employment of the zone in North-western Europe are given by Dean, Donovan and Howarth [25] and Elmi et al. [45].

In Bulgaria the name was first used by Nachev [15] into the section at the hamlet of Neshkovtsi as "Limestones with belemnites – *Harpoceras bifrons* Brug. Zone". Sapunov [24] have found that this "zone" includes ammonites from the *Hildoceras bifrons* zone at the base up to *Leioceras opalinum* zone at the top, and this made it too large and too distant from the original meaning of its usage. The employment of *H. bifrons* Zone in correct sense has been made by Sapunov [14] and the first biostratigraphic interpretation have been done into the introduction of the Toarcian ammonite zonal standard in Bulgaria [24].

Stratigraphy. The zone corresponds to the stratigraphic distribution of *Hildoceras*. Associates of *Dactylioceras (Dactylioceras)*, *Nodicoeloceras*, *Catacoeloceras*, *Mucrodactylites*, *Zugodactylites*, *Peronoceras* and *Porpoceras* are also present, though much more sporadically [34]. The earliest *Polyplectus* and *Pseudolioceras* in Bulgaria have been recorded from the bottom of the zone. *Haugia* and *Phymatoceras* arise at the top [38]. Last *Harpoceras* fade approximately into the middle of the zone.

The genus *Hildoceras* has been identified as a succession of four species of worldwide distribution following each other in ascending order, from *H. lusitanicum* Meister and *H. laticosta* Bellini to *H. bifrons* (Bruguière) and finally *H. semipolitum* Buckman. *Dactylioceras (Dactylioceras)* were recognized in big number of species which display a great morphological variability. An attempt to estimate that has been made recently, and at least three morphological groups were separated [34]. The endmost is that of *D. (D.) stresherense* Sapunov [23, 34] which represents extremely evolute ammonites with delicate overlapping of the whorls and trifurcate ribbing. An intermediate group of less evolute species is represented by *D. (D.) commune* (J. Sowerby), *D. (D.) holandrei* (d'Orbigny) and *D. (D.) athleticum* (Simpson). The third morphological group of *Dactylioceras (Dactylioceras)* is framed by species of more depressed whorls and coarser ornament, such as *D. (D.) crassiusculum* (Simpson) and *D. (D.) temperatum* (Buckman) (Fig. 3f, g). *Nodicoeloceras* are represented by *N. crassoides* (Simpson), surviving from the *H. falciferum* Zone (Fig. 3i, j), as well as from some cadicone species, e.g. *N. fontis* Guex [34]. *Zugodactylites* have been recently discovered in Bulgaria [34] and it seems that the main occurrence is that of the type species *Z. braunianus* (d'Orbigny) (Fig. 3k). *Peronoceras* have been discovered in Bulgaria at first in three species: *P. andraei* (Simpson), *P. fibulatum* (J. de C. Sowerby) [23] (a good example refigured here on Fig. 3n), and *P. krumbecki* Monestier [24]. Additionally good examples of *P. turriculatum* (Simpson), *P. subarmatum* (Young & Bird) and

P. perarmatum (Young & Bird) were identified and an ammonite from the first species was figured [34]. *Catacoeloceras* are still poor taxonomically studied, but its presence into the zone have been recognised by good examples of *C. crassum* (Young & Bird) [23] (Fig. 3l, m), *C. jordani* Guex and *C. dumortieri* (de Brun non Maubeuge). *Mucrodactylites* seem to be represented in general by examples of the type species *M. mucronatus* (d'Orbigny) [34], but it is apparent that two more species exist as well. Previously these were thought to be examples of the genus *Collina* [24]. Its taxonomical re-examination has shown that they are real *Mucrodactylites* having a typical distant simple lateral ribbing and zigzag-like ventral ornament of secondary ribs. Besides, *Collina* have been documented to appear higher up into the association of the *H. variabilis* Zone. The presence of *Porpoceras* in Bulgaria has been evidenced not long ago [32, 34] but still in an incomplete state of knowledge. It is interesting to note that most of the finds of this genus associate with the marls of the Boukorovtsi Member and therefore the ammonites are extremely flattened and difficultly identifiable. A previously figured example of *P. vortex* (Simpson) is refigured in this paper (Fig. 3h).

The other members of the association of the *H. bifrons* Zone in Bulgaria are: *Pseudolioceras lythense* (Young & Bird) [24, 35], *Harpoceras falciferum* (J. Sowerby), *H. subplanatum* (Oppel) [38], *H. soloniasense* (Lissajous), *Haugia* ex gr. *navis* (Dumortier) [38], *Polyplectus pleuricostata* (Haas) and *Phymatoceras cornucopia* (Merla) (Fig. 5k). Sapunov [24] identified few ammonites from the *H. bifrons* Zone to be of the genera *Mercaticeras* and *Harpoceratoides*. There are serious doubts about these identifications. Specimens referred to *Mercaticeras* represent in fact small *Hildoceras lusitanicum* with uncommonly depressed whorls, and there is no umbilical tuberculation. The reported "*Harpoceratoides connectens* (Haug)" and "*Harpoceratoides subserotinum* Sapunov" are in reality examples of *Harpoceras soloniasense*.

On the strength of the above reported record, the *H. bifrons* Zone has been determined in almost all localities and sections in the area under study. The best development of the zonal association belongs to the Boukorovtsi Member of the Ozirovo Formation at the section near the town of Teteven where an interval of 70 cm thickness includes large number of beautifully preserved ammonites. Other good sections are those near the village of Beledie Han [38] and section 'Dobravitsa-2' (90 cm thick). More thinly developed but well-defined, the zone was found into the section near the hamlet of Neshkovtsi [24], as well as the sections 'Kiselchov Dol' and 'Golyam Zhidov Dol'. These outcrops came in useful the zone to be subdivided into the subzones described below. The ammonite association of the *H. bifrons* Zone was found to be normally developed in its lower parts and condensed together with the ammonites of three ammonite zones of the Upper Toarcian in the section 'Dobravitsa-1'. It is uniquely represented just by Dactylioceratidae in the condensed Toarcian beds of the holostratotype of the Ozirovo Formation and the locality eastern of the village of Makotsevo [24, 28].

Scattered evidence appeared also from the exposures near the village of Gintsi [18, 24], from the section at the village of Milanovo and several localities near the village of Bov, eastwards the town of Etropole [9], to the south and to the north of the town of Teteven [7, 10, 24, 27], as well as from the section near the village of Shipkovo and from all exposures to the east of the Troyan Pass [13, 14–17, 24, 30]. The zone has been recently indicated in two boreholes near the town of Montana.

Two-way attempts at subdivision of the *H. bifrons* Zone in Europe exist. Following the classics of the Jurassic ammonite biostratigraphy as Buckman, Spath and Arkell, Dean, Donovan and Howarth [25] applied in Britain a three-fold subzonal set which is founded on the successive distribution of the Dactylioceratidae inside the zone. From the bottom to the top they are: Commune Subzone [confined by the ranges of *D. (D.) commune* (J. Sowerby) and *D. (D.) athleticum* (Simpson), and limited from above by the incoming of *Peronoceras*], Fibulatum Subzone [corresponding to the range of *Peronoceras*, and limited at the top by the first appearance of *Zugodactylites*] and Braunianus Subzone [defined by the range of *Zugodactylites*, being limited at the top by the advent of first *Haugia* and *Phymatoceras*]. Later was substituted, and the Crassum Subzone (characterized by the occurrence of *Catacoeloceras*, which was found subsequently to be better than *Zugodactylites* as being more frequent) is in use actually [50]. In France, a preference of subzonal subdivision based on the succession of the main species of *Hildoceras* has been given to. Gabilly et al. [54] introduced three subzones in rising order: Sublevisoni Subzone [= Commune Subzone plus the lower half of the Fibulatum Subzone as used in Britain], Bifrons Subzone [corresponding to the upper half of the Fibulatum Subzone sensu Dean, Donovan and Howarth] and Semipolitum Subzone [that agrees with the British Crassum Subzone]. The French authors argued that the succession of dactylioceratids used at the subzoning of the *H. bifrons* Zone by Dean, Donovan and Howarth is sufficiently stable to be followed within the British Isles only, and it is not easy to be recognized elsewhere. The same difficulty has been ran in Bulgaria too. The bulk of the Bulgarian Dactylioceratidae from the *H. bifrons* Zone exhibits very irregular pattern of distribution. Besides, some genera have been unknown until recently. The beds abounding in dactylioceratids belong usually to condensed strata. In much better cases there was a record but too fragmentary to be restored and the general picture has rose to view after a stratigraphic comparison on the base of the occurrence of *Hildoceras* species. Oftentimes the Dactylioceratidae are lacking into the zonal association at all. Therefore, the attempt for subzonal recognition which is proposed by Gabilly et al. [54] is apparently more successful, and it is accepted in much the same manner in this study.

Hildoceras lusitanicum Subzone

Index species. *Hildoceras lusitanicum* Meister, 1913. The holotype is from the Lower Toarcian at Marmeleira (Portugal), and it was figured by Meister (1913, pl. 12, Fig. 3) [55].

Remarks. Although there are more than 90 years since this name has been proposed, it is in more common use in course of the last decades. The same thing usually happens with another name, that of *H. laticosta*, which is contemporary species with *Hildoceras lusitanicum*. The reference of these species to either *Hildoceras levisoni* (Simpson) or *Hildoceras sublevisoni* Fucini and vice versa has been refuted by Howarth [50]. He demonstrated that the holotype of *Ammonites levisoni* Simpson, 1843, which was figured by Buckman (1910a, pl. 12) [48] represents in fact a small example of *Hildaites murleyi* (Moxon), having similar whorl proportions and rib density, and therefore it cannot be used as a name of *Hildoceras*. Howarth argued that the specific name "*laticosta*" takes a priority over the name "*sublevisoni*", which is proposed afterwards by Fucini (1922, p. 182) [56], although the original paper of Bellini from 1900 provided only a drawing of an ammonite from Umbria (Italy), and there is no real specimen of authentic record for reference. He convinced that the species can be correctly interpreted from Bellini's figure, because many specimens of well-dated occurrence from Umbria have been published by later authors and one of them, that figured by Merla (1933, pl. 7, Fig. 4) [57], matches exactly with the ammonite that has been drawn into the paper of Bellini. Contrary, Elmi et al. [45] ignore this priority having in mind that Fucini's name, as even being given later, is better to be used because it was based on well-recorded and still disposable original. This is an ammonite figured at first by Dumortier (1874, pl. 9, figs 3, 4) [58] and refigured by Elmi et al. (Pl. 9, figs 13, 14) [45]. The French authors declared that they are going to elicit a formal opinion from the International Commission on Zoological Nomenclature, but as such opinion is still not available, the priority belongs to the name proposed by Bellini.

Many ammonites of the index species of *H. lusitanicum* Subzone have been listed in Bulgaria before. Some of them were assigned to *H. levisoni*, other to *H. sublevisoni*. Two examples have been figured: an incomplete phragmocone from the Boukorovtsi Member of the Ozirovo Formation near the town of Teteven (Sapunov and Nachev, 1959, pl. 4, Figs 1, 2) [18] and part of the whorl of medium-sized specimen, from the Boukorovtsi Member of the Ozirovo Formation at section 'Dobravitsa-2' (Metodiev, 1997, pl. 2, Fig. 2) [32]. One wholly septate example, from the Boukorovtsi Member of the Ozirovo Formation, near the town of Teteven, previously listed by Sapunov (1968, p. 137) [24] as "*Hildoceras sublevisoni* Fucini" is figured in this paper (Fig. 4q).

Nomenclature. The subzone was used first by Gabilly et al. [54] as the lowest subzone of the Bifrons Zone which was called "Sublevisoni Subzone". It was framed by the succession of three ammonite horizons: Sublevisoni, Commune and Lusitanicum. In the current scheme of Elmi et al. [45] the original extent of the subzone is reduced and the Lusitanicum Horizon is incorporated into the Bifrons Zone. The subzone was initially announced to be separable in Bulgaria, recently [39]. In the present paper it is accepted in the same extent as proposed by Gabilly

et al. and this is the first use in Bulgaria. *Hildoceras lusitanicum* was preferred as index of the subzone instead of *Hildoceras laticosta* because it is better presented in the Lower Toarcian in Bulgaria.

Stratigraphy. The subzone is characterized by the occurrence of the index species and the coeval *H. laticosta* (Fig. 4o, p) by means that the top is limited at the last record of them and the mass-incoming of *H. bifrons*. The other species that compose the subzonal association are those of *Dactylioceras (Dactylioceras)*, *Nodicoeloceras*, *Harpoceras*, *Polyplectus* and *Pseudolioceras* as listed above into description of the zone. The former two seem to disappear in coincidence with *H. lusitanicum* and *H. laticosta*. *Harpoceras* lengthen upwards to the top of the next *H. bifrons* Subzone, whereas *Polyplectus* and *Pseudolioceras* extend higher up, but represented by different species which appear after a certain non-record into the Upper Toarcian *Grammoceras thouarsense* Zone. *Zugodactylites* seems to have a first appearance near the top. *Catacoeloceras* prolong its record from below, but still in low number.

Hildoceras bifrons Subzone

Index species. See *H. bifrons* Zone.

Nomenclature. The subzone was firstly employed by Gabilly et al. in the middle of *H. bifrons* Zone [54]. The original extent has been made wider by Elmi et al. [45] on the account of their older Sublevisoni Subzone from below that became narrower. Thereby, the *H. bifrons* Subzone, as initially used in Bulgaria [39] and here introduced, corresponds to the Apertum and Bifrons Horizons sensu Elmi et al. [45] (Fig. 2).

Stratigraphy. The *H. bifrons* Subzone is confined to the occurrence in abundance of its index. The index species vanishes at the top giving a way to the last link of *Hildoceras* lineage recorded in Bulgaria, that of *H. semipolitum*. *Peronoceras* come in sight at the bottom and *Zugodactylites* became much frequent. *Polyplectus* and *Pseudolioceras* range in this subzone yet again. The upper limit is drawn at the advent of first *Porpoceras*.

Hildoceras semipolitum Subzone

Index species. *Hildoceras semipolitum* Buckman, 1902. The holotype is the only remaining specimen figured by Buckman (1889, pl. 22, Figs 30, 31) [59]. According to Howarth (1992, p. 188) [51], it comes from the Cotswold Sands at Coaley Wood, near Stroud (Gloucestershire, England), and it is housed into the Sedgwick Museum (No J6304). The holotype is refigured by Howarth (1992, pl. 38, Fig. 8) [50].

In Bulgaria the index species has been reported before from three localities: in the section near the hamlet of Neshkovtsi [24, 30], in section 'Dobravitsa-1' [32] and from the section at the village of Beledie Han [38]. Small specimen from the area of the last section listed is figured in this study (Fig. 4r, s).

Nomenclature. This subzone is introduced by Gabilly et al. [54] as the uppermost subzone of the Bifrons Zone which is defined by the range of its index

species. Elmi et al. [45] relegated it to be the topmost horizon of the Bifrons Zone (Fig. 2). The subzone was firstly used in Bulgaria in its original sense [39], and it is incorporated into the Bulgarian ammonite zonal standard in this paper.

STRATIGRAPHY. The upper limit of the *H. semipolitum* Subzone is drawn immediately above the last occurrence of the index species. *Mucrodactylites* and *Catacoeloceras* are common. The former genus promptly fades away upwards at the base of the Upper Toarcian, on the account of *Collina*. The *Catacoeloceras* continue ranging higher up into the *Haugia variabilis* Zone. The first *Haugia* and *Phymatoceras* arise somewhere at the top. The incoming of *Porpoceras* concurs with that of the index species and it seems that both become extinct in coincidence at the end of the subzone.

U P P E R T O A R C I A N

***Haugia variabilis* Zone**

INDEX SPECIES. *Haugia variabilis* (d'Orbigny, 1884). According to Gabilly and Mouterde (In: FISCHER, 1994) [60] the ammonite which has been figured by D'ORBIGNY (1884, pl. 114, Figs 1-4) [61] was proved to be the only one specimen, but it is lost. Revision of the originals that belong to collection of d'Orbigny led to the recognition of a big number of specimens catalogued under the name "*variabilis*", but only one was found to be of this species and it is a lectotype. The lectotype is from the region of Autun (Saône-et-Loire, France), and was figured by Gabilly and Mouterde (1994, pl. 33, Figs 3a–c) [60]. It is kept into the Museum of Natural History, Paris (No 1924-1).

In Bulgaria the index species has been recognized in only one specimen, collected from an exposure of the Boukorovtsi Member of the Ozirovo Formation, located to the west of the village of Gintsi. One specimen from the Ozirovo Formation at the section of the village of Shipkovo has been identified as *Haugia* cf. *variabilis* by Sapunov [24]. It is more likely, however, that this ammonite does not belong to the index species and it probably refers to *Haugia phillipsi* (Simpson).

NOMENCLATURE. Introduced by Buckman [59] as a subzone at the base of Oppel's large Jurense Zone, it is individualized soon after that as a separate zone and in the same face it is in use more than one hundred years. Detailed reference about the employment and synonymy of the zone into the classical Jurassic literature is given by Dean, Donovan and Howarth [25]. The British authors did not offer any subzonal separation. It is probably because the zonal association frequently occurs in condensed sequences or it is absent in Britain. That has been made firstly in France by Gabilly et al. [54] on the fossil successions which were found in Poitou, on a manner that three subzones grew up to be in use. Perhaps, the best development of the *H. variabilis* Zone in Europe is that from the stratotype region of the Toarcian in Poitou, as well as from the exposures discovered in South-eastern France, and zonal and subzonal definitions proposed into the current scale of Elmi et al. [45] are advisable.

In Bulgaria, the *H. variabilis* Zone was first introduced by Sapunov [24], as the topmost zone of the Lower Toarcian. It has been retained to be the basal zone of the Upper Toarcian by Metodiev [36]. As *Haugia* are very uncommon in Bulgaria, they were thought to be of less biostratigraphical value than in NW Europe [24, 36]. The status and application of the zone into the Bulgarian ammonite standard have recently been discussed [36], and this discussion was in two minds – to save or to reconsider the name of the zone by using some other index and new definition. Since *Haugia* became much more apparent into the beds which were assigned to the zone, and to be in order with tradition, the *H. variabilis* Zone is carried on being in employment. The newly obtained ammonites enabled to fill up the list of characteristic species that define the zone in Bulgaria and to propose some subzonal subdivision, even though in still informal state of usage.

Stratigraphy. The zone is defined by the stratigraphical distribution of several genera of unequal occurrence: *Haugia*, *Brodieia*, *Phymatoceras*, *Denckmannia*, *Catacoeloceras*, *Mucrodactylites* and *Collina*. The upper limit is drawn immediately below the first appearance in abundance of *Pseudogrammoceras* and *Podagrosites*. The zone has been found to be satisfactorily developed in three sections: Beledie Han [38], 'Dobravitsa-2' in both 50 cm thick and section 'Kiselchov Dol' (30 cm thickness). These exposures yielded the main portion of the newly collected material. The zone takes part of a condensed bed in section 'Dobravitsa-1' [32], as well as in the Boukorovtsi Member of the Ozirovo Formation near the village of Milanovo. Sapunov [24, 30] found it to be thinly developed into the section at the hamlet of Neshkovtsi. The zone is indicated in several localities from the Area of Zaburde [24], and in section 'Golyam Zhidov Dol' as well.

Even being preserved occasionally, *Haugia* seems to cover the total extent of the zone, and they are represented as follows: *Haugia* cf. *variabilis* (d'Orbigny), *Haugia evoluta* Gabilly (Fig. 5a), *Haugia* aff. *phillipsi* (Simpson) [24], *H. jugosa* (Sowerby) and *H. vitiosa* (Buckman) [38]. Single *Brodieia* were also found and one of them is figured (Fig. 5b). The *Phymatoceras* occur into the lower part of the zone (Fig. 2), probably being attributable to three species: *P. iserense* (Oppel), *P. robustum* (Hyatt) and *P. narbonense* Buckman (sensu lato). Its distribution coincides with that of *Catacoeloceras* which were recognized into three species: *C. raquinianum* (d'Orbigny) [34], *C. confectum* Buckman and *C. puteolum* (Simpson). The last occurrence of *Mucrodactylites* was recorded and it was that of *M. freboldi* (Monestier).

Surprising results have been obtained two years ago in the course of the study of section 'Dobravitsa-2'. It has been found to contain a half metre extent of *H. variabilis* Zone with many examples of *Collina* preserved into the lower 25 cm. Two ammonites from this exposure are figured (Figs 5e–g). This interval was clearly separated from an abundant occurrence of *Hildoceras* (below) and rich assemblage of *Pseudogrammoceras* and *Podagrosites* (above), but such kind of development of the zone has been unknown in Bulgaria before.

The upper part of the *H. variabilis* Zone seems to be covered mainly by the range of the genus *Denckmannia*. Pervious Bulgarian literature yielded several specific names that belong to this genus, described firstly as "*Lillia*" [18], thereafter listed under the names "*Phymatoceras (Chartronia)*" or just "*Chartronia*" [24, 30, 32, 33, 36]. This is a question which unfortunately is not resolved yet. It was obvious that two types of ammonite morphology occur within the upper part of the zone:

1) More evolute and more depressed ammonites with roughly quadrate whorl section that is surmounted by thick ventral keel, bordered by flat areas or sulci. The ornament is robust and composed of rursiradiate ribs which curve slightly forwards at the ventrolateral edge, usually twinned from the umbilical edge in thick tubercles during the earlier growth stages. Deep constrictions sometimes bound the pairs of ribs. The ribbing becomes simple and more obliterated with the progress of coiling. This morphological group is believed here to represent real *Denckmannia*, and four species were identified: *D. obliquata* (Young & Bird), *D. erbaensis* (von Hauer), *D. rudis* (Simpson), *D. fabalis* (Simpson) (an example is figured in this paper on Fig. 5c, d), and *D. malagma* (Dumortier) (also figured herein, see Fig. 5h).

2) Less evolute and more compressed ammonites with quadrate whorls at inner stages of coiling that became elliptical. The ornament is denser and more flexuous. An ammonite from this group is shown in this study (Fig. 5i, j) and it represents the examples that were called "*Chartronia*".

At the present state of study it is not easy to take a taxonomic decision and this work is contented to just giving briefly the known facts in the hope that a special paper concerning that problem is forthcoming soon. Because the ammonite association of the *H. variabilis* Zone is still poorly understood, the above represented data would not be estimated if they apply throughout the Balkan Mts Area or it concerns to events with local value. It seems, however, that the zone could be initially separated in two informal subzones: *Collina* spp. Subzone, which is recognizable by the distribution of ammonites of the genera *Collina*, *Phymatoceras*, *Catacoeloceras* and *Mucrodactylites* (underneath), and *Denckmannia* spp. Subzone that is discernible by the occurrence of this genus into the upper part. A lot of work is needed to be done in order these subzones to be better defined and adequate indexes to be nominated. Nevertheless, the *H. variabilis* Zone is considered to be a good match with the Variabilis Zone as employed by Elmi et al. [45]. It is presumable that the *Collina* spp. Subzone corresponds to the extent of the Variabilis Subzone and the Illustris Horizon of the Illustris Subzone and the *Denckmannia* spp. Subzone refers to the Phillipsi Horizon of the Illustris Subzone and the Vitiosa Subzone, as they were given into the French scale.

***Grammoceras thouarsense* Zone**

INDEX SPECIES. *Grammoceras thouarsense* (d'Orbigny, 1843). The lectotype figured by d'Orbigny (1843, pl. 57, Figs 1-3) [61] is gone as pointed out by Gabilly

and Mouterde that figured another original specimen (1994, pl. 34, Figs 1a, b; 2a, b) [60]. This syntype came from the Upper Toarcian at "Chevillé, Sartre", France, and it takes a part of collection of the Museum of Natural History in Paris (No IPM-B. 9075). The best evidence concerning the taxonomy and the biostratigraphy of the index species and other allied taxa are given in the work of Rulleau [62].

The index species is discovered in many exposures of the Balkan Mts Area. It was firstly figured by Sapunov (1968, pl. 3, Fig. 1) [24] in a specimen from unrecorded locality of the Troyan Balkan. An adult from the Boukorovtsi Member of the Ozirovo Formation at section 'Dobravitsa-1'which was figured thereafter by Metodiev (1997, pl. 3, Fig. 3) [32]. It is refigured in this paper (Fig. 5t). The species was studied in Bulgaria more in detail a short while back, and the most recent description with given reference of localities and some ammonites figured can be found [33].

Nomenclature. According to Dean, Donovan and Howarth [25], this name appeared first into the literature in two successive papers of Brasil from 1895 and 1896 on the Upper Toarcian ammonite-bearing beds in Normandy. They considered that in the same sense as at present, the zone was firstly used fifteen years later by Welsch. The British team proposed the *G. thouarsense* Zone to be defined by the occurrences of *Grammoceras* and *Pseudogrammoceras*, assuming that the advent of the former genus is prior to that of the later-one. In this way the zone was constituted by two subzones: Striatulum Subzone (with predominant distribution of *Grammoceras*) and Struckmanni Subzone (defined by *Pseudogrammoceras* occurrence). Careful reading of the brief details about the development of these subzones in Britain given led to that each of them is recognised in condensed sequences and therefore they are of local use. The definition and subzonal discrimination of the zone were made in better way by Gabilly et al. [54] and improved by Elmi et al. [45].

In Bulgaria, the *G. thouarsense* Zone came into use in the paper of Sapunov [24]. Later on, Metodiev have found a requirement the zone to be redefined [33]. In consequence, the *G. thouarsense* Zone has been determined in different manner, and reduced in extent by separation of the *Pseudogrammoceras fallaciosum* Zone from above.

Stratigraphy. The zone is well developed and said to be defined by the combined ranges of *Pseudogrammoceras, Grammoceras* and *Podagrosites* [33]. Recently *Esericeras* were proven to take part into the zonal association [38]. The lower limit was redrawn by the appearance of *Pseudogrammoceras* and *Podagrosites* particularly that of *Pseudogrammoceras subregale* Pinna, *Pseudogrammoceras struckmanni* (Denckmann), and *Podagrosites aratum* (Buckman). The upper limit is now defined to be keeping up with the co-extinction of *Grammoceras* and *Esericeras*. *Polyplectus* suddenly prolong its occurrence from the Lower Toarcian after a non-record into the *H. variabilis* Zone, by virtue of its

type species *P. discoides* (Zieten). *Osperleioceras* were registered to have its first occurrence in Bulgaria into the association of this zone, by the identification of the classical species *O. bicarinatum* (Zieten) [37].

The best developments of the zone in Bulgaria that enabled recently a subzone separation have been found in four sections: at the village of Beledie Han [38], in section 'Dobravitsa-2' where it displays the biggest thickness (60 cm), as well as in sections 'Kiselchov Dol' and 'Golyam Zhidov Dol' where it is much thinly developed but well-defined by its subzones. The zone has been established much thinner in the section near the hamlet of Neshkovtsi by Sapunov [24, 30]. It was found in condensed strata from five sections: 'Dobravitsa-1' [32], into the holostratotype of the Ozirovo Formation [24, 29], in the section at the village of Milanovo and to the south of the hut of 'Ambaritsa' [30]. By different members of the zonal association it has been indicated in many localities from the region of Zaburde, near the town of Teteven, and on the Dulgi Dyal Ridge [24, 27, 30].

Three names were initially nominated for subzonal indexes within the *G. thouarsense* Zone in Bulgaria: *Pseudogrammoceras bingmanni* (Denckmann), *G. thouarsense* and *Esericeras fascigerum* (Buckman) [39], assuming that a subdivision at subzonal level became possible in similar manner as proposed by Elmi et al. [45]. The subzones used as constituents of the zone were founded on closely related forms and that was perfectly demonstrated in France [45, 54, 62]. Therefore the species which are recorded in Bulgaria are listed below in terms of the subzones into which they occur. In contradistinction from the French scale, however, *Pseudogrammoceras fallaciosum* occurrence has been led away of the *G. thouarsense* Zone, and separated into a different zone itself [33] (see also notes below).

Pseudogrammoceras bingmanni Subzone

Index species and Nomenclature. Two syntypes were described and figured by Denckmann (1887, p. 71, pl. 5, Fig. 4, pl. 6, Fig. 5) [63] and one of them (Denckmann, 1887 pl. 6, Fig. 5) was designated lectotype by Gabilly (1975, p. 137) [64]. According to Gabilly they come from "bed 6" at former ironshot quarry 'Georg Friedrich" near Dörnten, SW Germany. The syntypes were refigured by Gabilly (1975, pl. 24, Figs 1-7) [64]. In Bulgaria, the index species is very common. Two good examples were figured (Metodiev, 2002, pl. 3, Figs 5, 6) [33] and one of them is refigured here (Fig. 5x, y). The subzone as employed in this study is believed to be an exact equivalent of subzone of the same name introduced by Gabilly et al. [54] and used into the current scale of Elmi et al. [45] (Fig. 2).

Stratigraphy. The subzone is limited from above by the advent of *Grammoceras* whose range seems to begin with *G. striatulum* (J. Sowerby) [33]. This extent includes the occurrences of several species, from among of them few examples are shown in this study: *P. subregale* Pinna, *P. bingmanni* (Denckmann), *P. struckmanni* (Denckmann) (Fig. 5u), *P. muelleri* (Denckmann) (Fig. 5n, o), *Podagrosites aratum* (Buckman) (Fig. 5l, m), *P. bodei* (Denckmann) and *P. quadratum* (Quenstedt) [38].

Grammoceras thouarsense Subzone

Index species and Nomenclature. See *G. thouarsense* Zone.

Stratigraphy. The subzone corresponds to the total range of *Grammoceras*. The upper limit is drawn immediately below the last occurrence of the genus which is in coincidence with that of *Esericeras*. In this development the subzone is found to contain the following species: *G. thouarsense* (d'Orbigny), *Pseudogrammoceras explicatum* Buckman, *P. subquadratum* Buckman, *P. pachu* Buckman (Fig. 5v), *P. thrasu* Buckman, *Podagrosites latescens* (Simpson) (Fig. 5q), *P. pseudogrunowi* Guex (Fig. 5p), *P. ponorensis* Metodiev, *Polyplectus discoides* (Zieten) and *Osperleioceras bicarinatum* (Zieten).

Esericeras fascigerum Subzone

Index species. *Esericeras fascigerum* (Buckman, 1899). The holotype was figured by Buckman (1890, pl. 25, Fig. 7) [59], and it is from the Upper Toarcian "Striatulum-beds" at Stinchcombe Hill, (Gloucestershire, England). One good example, from the Ozirovo Formation at the section near the village of Beledie Han is shown in this study (Fig. 5w).

Nomenclature. The subzone was introduced by Gabilly et al. [54] and takes part of the current scale of Elmi et al. [45]. It is used for the first time in Bulgaria in the same sense into this study.

Stratigraphy. The subzone is defined by the occurrence of two species of the genus *Esericeras* – *E. fascigerum* Buckman and *E. eseri* (Oppel) [38]. In addition, the subzone is characterized by *Grammoceras penestriatulum* Buckman and *Pseudogrammoceras pseudostruckmanni* Gabilly, both in much more sporadic distribution.

***Pseudogrammoceras mediterraneum* Zone**

An exceptional development of the span of the *G. thouarsense* Zone has been recorded from the section at the village of Dragovishtitsa [33]. This section was proved to be with no record of *Grammoceras*. The ammonite association below one bed abundant in *Pseudogrammoceras fallaciosum* is waited to be with *Grammoceras* occurrence. However, it was found to be similar to a succession described from the Upper Toarcian of region of Granada in Spain by García-Gómez and Rivas [65]. This extend was named as *Pseudogrammoceras mediterraneaum* Zone and it is of local value. Because it was already described and the characteristic species were figured, it is not represented into this paper as the rest of the zones from the set given. This is done below in tabular form in order to illustrate the sudden break of the conventional record which seems to be evidence of Mediterranean influence (Table 1, see also Fig. 2).

***Pseudogrammoceras fallaciosum* Zone**

Index species. *Pseudogrammoceras fallaciosum* (Bayle, 1878). The holotype (collection of High School of Mining in Paris) was figured by Bayle (1878, pl. 78, fig. 6) [66], and it came from the vicinities of Urweiler, Lorraine. It is refigured

Table 1

Comparison table between distributions of the species within *Pseudogrammoceras mediterraneum* Zone in section Cerro Méndez (Allamedilla, Granada) and section at the village of Dragovishtitsa (Western Balkan Mts, Sofia District)

Sucesión faunística de la secuencia de Cerro Méndez (Allamedilla, Granada) after García-Gómez and Rivas [65]	Species distribution within the local *P. mediterraneaum* Zone in section at the village of Dragovishtitsa after Metodiev (2002) [33]
7. *Pseudogrammoceras* gr. *fallaciosum* (Bayle) representados principalmente por *P. pedicum* Buckman y formas afines.	*Pseudogrammoceras fallaciosum* Zone
6. *Pseudogrammoceras retrocostatum* sp. n. *P. andalusiensis densicostatum* subsp. n. *P. andalusiensis* sp. n. (frecuente) *P. mediterraneum* sp. n. (frecuente)	*Pseudogrammoceras densicostatum* (Metodiev, 2002, pl. 1, fig. 13) *Pseudogrammoceras mediterraneum* (Metodiev, 2002, pl. 1, fig. 11)
5. *P. mediterraneum* sp. n. (poco frecuente) *P. garnatensis* sp. n.	*Pseudogrammoceras garnatensis* (Metodiev, 2002, pl. 1, fig. 12)
4. Intervalo 3. *Pseudogrammoceras pinnai* sp. n.	+ *Pseudogrammoceras pinnai* (Metodiev, 2002, pl. 1, fig. 10)
2. *Pseudogrammoceras subregale* Pinna	*Pseudogrammoceras subregale* (Metodiev, 2002, pl. 1, fig. 19)
1. *P.* gr. *subregale* Pinna *Pseudogrammoceras aratum* (Buckman)	+ *Podagrosites aratum*

by Gabilly (1975, pl. 30, Figs 1–4) [64]. The best studies devoted to this species are those of Gabilly and Rulleau [62, 64].

Many exposures from the Balkan Mts Area are very abundant in that species. A full revision of the older collections that contain examples of the index with addition of the newly obtained material has been made recently [33]. A wholly septate example, from the Ozirovo Formation of the section at the hamlet of Neshkovtsi is figured into this paper (Fig. 5z).

Nomenclature. According to Elmi et al. [45] the first incoming of this name was in 1941 and it was proposed by Muller. Gabilly et al. [53] and Gabilly [63] used it as a lower subzone of the Insigne Zone which corresponds to the *Phlyseogrammoceras dispansum* Subzone sensu Dean, Donovan and Howarth [25]. It is put into the current scale of Elmi et al. [45] as the uppermost Subzone of the *Grammoceras thouarsense* Zone. Metodiev enhanced it to be a zone [33], and in this way it has been employed afterwards in Bulgaria, in this paper also. There main argument to do that was the evidence that almost everywhere in Bulgaria the beds that contain *P. fallaciosum* are particularly abundant in this species. In this sense they are quite distinct from the rest of *Pseudogrammoceras* record.

Stratigraphy. The zone corresponds to the occurrence in abundance of

its index species, and it ends sharply, usually by lack of ammonites from above. The best development of the zone emerged from the section 'Dobravitsa-2' where it is 60 cm thick. Another good exposure is that of the section Beledie Han where the zone has been well-dated recently [38]. In almost the same manner, the *P. fallaciosum* Zone has been established in the section near the village of Dragovishtitsa. Thinly developed but evident, it has been proven in the section near the hamlet of Neshkovtsi [24] as well as in sections 'Kiselchov Dol' and 'Golyam Zhidov Dol', in each of them into 20 cm thick beds. Eastwards of these sections it was found to become thicker in the localities on the Dulgi Dyal Ridge as well as in section 'Broussovete' [30]. The zone is partly condensed in section 'Dobravitsa-1'. Many indications, but in low number of specimens from every locality, have been obtained from the exposures through the region of Zaburde, around the town of Teteven as well as from the Ponor-Kremikovtsi Jurassic Strip. It seems that in several boreholes located near the town of Montana, the *P. fallaciosum* Zone has its thicker development, in the extend which does not exist in the outcrops. They will be a subject of different study and therefore not be described here.

These brief notes represented now are because at the introduction of the zone in Bulgaria they have not been given. The paper, into which it has been made, includes a reference of the taxa that are characteristic to the zone. Many of these have been described and figured (Metodiev, 2002, Fig. 2, pp. 170–171, pp. 183–188, Pls 3–6) [33]. Thereby the species which are associated to the zone are just listed herein without any other comments: *Pseudogrammoceras fallaciosum* (Bayle) (understood in a broad sense, as being found previously to be widely variable in morphology and described in six morphotypes), *P. pseudostruckmanni* Gabilly, *P. differens* Ernst, *Podagrosites podagrosum* (Monestier), *P. pseudogrunowi* Guex, *Polyplectus discoides* (Zieten) (Fig. 5r, s) and *Osperleioceras bicarinatum* (Zieten) [38]. In addition, the range of the genus *Pseudolillia* has been recently lengthened upwards into this zone, by the identification of *P. donovani* Garcia-Gomes & Rivas [38] and the re-assignment of *P. emilliana* (Reynès) (see Fig. 6c–e).

***Phlyseogrammoceras dispansum* Zone**

Index species. *Phlyseogrammoceras dispansum* (Lycett, 1860). The holotype was figured by Buckman (1922, pl. 340) [48], and it is from the "Cotswold Sands", at Frocester Hill (Yorkshire, England). The index species seems to be in sporadic occurrence in Bulgaria. It has not been figured before, and Fig. 6a represented into this paper is the first shot of an ammonite from Bulgarian locality. It was collected from the Ozirovo Formation at the section near the village of Dragovishtitsa.

Nomenclature. According to Dean, Donovan and Howarth [25] the first usage of this name was the "*Dispansum* Beds" by Buckman [59]. It has been found by the same authors to have a lot of synonyms into the older literature,

usually employed as a subzone of Oppel's Jurense Zone. The zone has a subzonal statute in their scale as well, but going to the bottom of a large Levesquei Zone which was believable to cover the co-occurrence of the genera *Phlyseogrammoceras*, *Dumortieri*a and *Pleydellia*. In one of the earliest works of Gabilly [67] it was used as subzone of the "Zone à *Lytoceras jurense?*", but under a separate cover, below the *Dumortieri*a and *Pleydellia* record which were comprehended to define different zones upwards to the top of the Toarcian. A double usage of names exists in this study, and the second index which was nominated together with *Phlyseogrammoceras dispansum* is that of *Hammatoceras insigne*. Later, it has been preferred to be employed as index species for a long time and this unit was consequently erected into a zone. Upon consideration *P. dispansum* was reinstated as zonal index, such as it is into the scale of Elmi et al. [45] at present.

No authentic record caused this zone was not be into the zonal set at the introduction of the Toarcian standard in Bulgaria [24]. Not until the last decade, the *P. dispansum* Zone became recognizable in the outcrops of the Balkan Mts Area. The zone came into use in Bulgaria after a work of Metodiev and Sapunov [37].

Stratigraphy. The incoming of the ammonite association that defines the *P. dispansum* Zone in Bulgaria has been documented directly in only few sections. It has been recognized on the occurrences of several species of *Phlyseogrammoceras*. *Hudlestonia* and *Pseudolillia* appear to be also present, though too accidentally. The zone is limited from below at the last occurrence of *Pseudogrammoceras*. The top is drawn by the incoming of *Dumortieria*. Metodiev and Sapunov have found the zone to be well-developed firstly in the Ozirovo Formation at the section near the village of Dragovishtitsa [37]. Before that, it was just indicated by few specimens from the condensed beds of the holostratotype of the Ozirovo Formation [24, 29], or supposed to be present into the Ponor-Kremikovtsi Jurassic Strip [26]. The section at the village of Dragovishtitsa enabled two species to be recognized on previously collected material: *P. maubeugei* sp. n. (refigured here – Fig. 6b) and *P. bleicheri* (Maubeuge) [37]. The ammonites which were obtained from the holostratotype of the Ozirovo Formation have been interpreted to represent a subspecies of *P. dispansum* (Lycett) and because of its wider umbilicus they have been named *P. dispansum evolutum* [37]. Soon after that, the index species have been discovered in the beds near the village of Dragovishtitsa (the ammonite figured in Fig. 6a). Another specimen newly collected from this section has been identified as *Phlyseogrammoceras beneckei* Maubeuge (Fig. 6g). An addition to the ammonite record of this section has been made by the discovery of small ammonites that lengthened upwards the record of the genus *Pseudolioceras* in Bulgaria – *P. alienum* Dagis [35]. The nearly located section at the village of Beledie Han yielded one more *Phlyseogrammoceras*, identified in approximation to be *Phlyseogrammoceras* ex gr. *dispansiforme* (Wunstorf), and *Pseudolillia emilliana* (Reynès) [38]. The *P. dispansum* Zone has recently been indicated in sections 'Kiselchov Dol' and 'Golyam Zhidov Dol', where several still unidentified ammonites were found.

An unexpected development of the zone came from the beds of the Boukorovtsi Member of the Ozirovo Formation at section 'Dobravitsa-1'. Above the last occurrence of *Pseudogrammoceras* and below the first record of *Dumortieria*, a 20 cm thick interval of marls suddenly has been found to contain exclusively ammonites of *Hammatoceras* appearing to be examples of at least four species. One of them has been identified as *Hammatoceras speciosum* Janensch and it is shown in this paper (Fig. 6f).

***Dumortieria pseudoradiosa* Zone**

INDEX SPECIES. *Dumortieria pseudoradiosa* (Branco, 1879). The initial work of BRANCO contains drawings of three ammonites, from "Schichten mit *Trigonia navis*" at Boevingen (Lorraine), which were assigned to a new species under the name "*Harpoceras pseudoradiosum*" (Branco, 1879, pl. 2, Figs 1–3) [68]. Buckman (1890, p. 246) [59] recognized later that specific proposal but only on the first of Branco's figures, and it must be considered to be the holotype. There is no current evidence if that specimen is still available. The index species has recently been identified in Bulgaria, and one good example from the Ozirovo Formation at section 'Kiselchov Dol' is figured here for the first time (Fig. 6n).

NOMENCLATURE. According to Elmi et al. [45] the origin of the name is traced to the work of Haug from 1892, since which time it has been long used under different headings as a subdivision of the Jurense Zone. Buckman's Dumortierian Age [48], comprising *Hammatoceras*, *levesquei*, *novata*, *subsolaris*, *Catulloceras* and *moorei* hemerae, is probably the first comprehension of the extent of the zone which is normally accepted today. One of the earliest employments of the zone at the present sense is likely to be that of Gabilly [67] who separated the "Zone à *Dumortieria levesquei* et *D. pseudoradiosa*" above the Jurense Zone, later understood to be inclusive of four subzones from *Haugia variabilis* to *Phlyseogrammoceras dispansum* record. The equivalent of the *D. pseudoradiosa* Zone into the British literature is the aggregate of *Dumortieria levesquei* and *Dumortieria moorei* Subzones which take a part in the middle of a large *D. levesquei* Zone that covers the total extent from the *Phlyseogrammoceras dispansum* to the *Pleydellia aalensis*, both used as subzones at the base and at the top [50].

In Bulgaria *Dumortieria* record has become recognizable in zonal meaning after the introduction of the ammonite standard, when Oppel's Jurense Zone was rejected and two zones came into use: Levesquei and Moorei Zones [24]. It was adopted that a two-fold pattern of distribution of coarsely ribbed species of *Dumortieria* "*levesquei*-Gruppe" and fine ornamented *Dumortieria* "*radiosa*-Gruppe" exists within the total range of *Dumortieria*. The main evidence for this assumption appeared from the section near the hamlet of Neshkovtsi, which, however, was recently found to be incomplete in respect to the fossils collected. In the recently discovered section 'Kiselchov Dol', which is closely located to that at the hamlet of Neshkovtsi and recover it almost completely as lithological succession, such kind of distribution was not followed. A reasonable question,

are *D. levesquei* and *D. moorei* Zones usable came forwards. The answer has got thereafter by the study of the section at the village of Dragovishtitsa and especially that of the section near the village of Beledie Han where the zone was used in the manner of this paper at first [38]. The coincidence in incoming of the two morphological groups at the lower part of the range of *Dumortieria* has been documented and led to the rejection of *D. levesquei* and *D. moorei* Zones. Besides, *D. moorei* was found to be quite rare and endmost species of the range of *Dumortieria*. Therefore it has been considered to be unsatisfactory as a zonal index. In this paper the *Dumortieria pseudoradiosa* Zone is described at first in Bulgaria, in conviction that it is firmly comparable with the Pseudoradiosa Zone as employed by Elmi et al. [45]. Recently, two names were initially nominated for subzonal index species within the zone: *D. levesquei* and *D. pseudoradiosa* [39]. The arguments to doing that are given below.

Stratigraphy. The zone corresponds to the stratigraphical range of the genus *Dumortieria* which is documented somewhere to follows that of *Phlyseogrammoceras*, elsewhere that of *Hammatoceras*. The upper limit is drawn more or less at the maximum recorded occurrence of *Dumortieria*, below the incoming of the genus *Pleydellia*. The zonal association is remarkable for being represented only by ammonites of *Dumortieria*. Just one exception was recently found and this is *Pseudolioceras beyrichi* (Schloenbach) [35]. Specimens which were previously referred to the genus *Catulloceras* and assigned to this zone [24, 29], are in reality different species of *Podagrosites*, and all of them derive from condensed strata without authentic stratigraphical record. Therefore *Catulloceras* still remains to be uncertain in Bulgaria, in distinction of many extra-Bulgarian areas where this genus is common.

The species which were discovered within the range of *Dumortieria* in Bulgaria are given below in the frames of the subzones that constitute it. It must be admitted that the lists of the species reported are not completed and some additions are impending. As it was stated above, three sections yielded the main portion of ammonites of gaugeable occurrence: section at the village of Dragovishtitsa, where the zone is 50 cm thick, section near the village of Beledie Han which has already been described [38] and section 'Kiselchov Dol', where the zone is 40 cm thick. In the section at the hamlet of Neshkovtsi the zone covers 35 cm thickness [24, 30]. Another good source of the zone is that into the section 'Golyam Zhidov Dol' where, however, it is much thinly developed. Section 'Dobravitsa-1' has recently been found having better development of the zone. Few occasional specimens were identified in one borehole near the town of Montana.

Dumortieria levesquei Subzone

Index species. *Dumortieria levesquei* (d'Orbigny, 1844). The lectotype, designated by Gabilly and Mouterde (1994, p. 59) [60] is the specimen figured by d'Orbigny (1884, pl. 60) [61] which is from the Upper Toarcian at Autun (Saône-et-Loire), France. It is kept into the collections of the High School of Mining in Paris (No IPM-B. 9769), and it was figured photographically by Gabilly and Mou-

terde (1994, pl. 36, Figs 3a, b). The index species is common in Bulgaria, and it was reported several times from different localities [24, 26, 28, 30, 32]. A wholly septate specimen, from the Ozirovo Formation at section near the village of Dragovishtitsa is figured here (Fig. 6h).

NOMENCLATURE. The name was used first by SPATH (1942, p. 265) [69] as a subzone of the Jurense Zone. It was erected to be a zone by MOUTERDE [70] north of the Massif Central but of affiliation of the Bajocian. In Britain it is used as subzone of more extended *D. levesquei* Zone. In Bulgaria it was introduced as a zone into the Toarcian ammonite standard and used like that for a long time [24, 26, 29, 30, 32, 37], but recently relegated to be an exact match of the Levesquei Subzone sensu Elmi et al. [45] (Fig. 2).

STRATIGRAPHY. The taxonomic composition of the subzone is not well-studied yet, but it seems that it is defined by the occurrences of the following species: *Dumortieria levesquei* (d'Orbigny), *D. prisca* Buckman (Fig. 6i), *D. insignisimilis* (Brauns) (Fig. 6j), *D. pannonica* Géczy (Fig. 6k), *D.* cf. *munieri* Haug, *D. kochi* Benecke, and *D. leesbergi* Branco.

Dumortieria pseudoradiosa Subzone

INDEX SPECIES and NOMENCLATURE. See *D. pseudoradiosa* Zone. The name was first interpreted in this manner by Gabilly et al. [54]. In Bulgaria it was recently employed in the same sense [39] in order to lead away of use Moorei Zone sensu Sapunov [24]. The subzone correlates to the Pseudoradiosa Subzone of the current scale of Elmi et al. [45] (Fig. 2).

STRATIGRAPHY. The subzone has been defined by distribution of the following species: *Dumortieria pseudoradiosa* (Branco), *D. multicostata* Buckman (Fig. 6l), *D. rhodanica* Haug (Fig. 6m), *D. regularis* Buckman (Fig. 6o), *D. explanata* Buckman (Fig. 6p), *D. tabulata* (Buckman), *D. nicklesi* Benecke, *D. gundershoffensis* Haug, *D. linearis* Buckman, *D. striatulocostata* (Quenstedt), *D. cf. moorei* (Lycett), *D. munda* Buckman, *D. arenaria* Buckman, *D. mutans* Buckman, as well as some specifically inseparable specimens roughly identified as *Dumortieria* ex gr. *radians – radiosa* (Reinecke).

***Pleydellia aalensis* Zone**

INDEX SPECIES. *Pleydellia aalensis* (Zieten, 1832). The holotype is the original of Zieten's (1832, pl. 28, Fig. 3) [71] figure, and is from the "Schichte der Lias-Schiefers" near Aalen, Württemberg, SW Germany.

Many ammonites from the Toarcian of the Balkan Mts Area have been refered to the index [7, 14, 16, 17], but it became apparent that only one of them belong to this species. It is the ammonite from the Ozirovo Formation at the section near the hamlet of Neshkovtsi which was figured by Sapunov (1968, pl. 3, Fig 5) [24]. The revision of the older collections led to the conclusion that some of the specimens listed into the previous literature were lost and the others are assigned to different species of genus *Pseudogrammoceras*. More recently, the index species has been recognized in few ammonites from the Boukorovtsi Member of the

Ozirovo Formation in section 'Dobravitsa-1'. One of them was figured (Metodiev, 1997, pl. 4, Fig. 8) [32], and it is refigured in this paper (Fig. 6q).

NOMENCLATURE. The zone was first applied by Reynès [52] in position above the Jurense Zone. According to Dean, Donovan and Howarth [25] it was employed in the same manner as late as Spath [69] correctly retained it in the Toarcian, following the original definition of the stage. The first attempt for subzonal subdivision at the present sense belong to Mouterde [70] by the recognition in strata northwards the Massif Central of a horizon of *Pleydellia mactra* (Dumortier) underlying that of *P. aalensis*. In Bulgaria the *P. aalensis* Zone was introduced by Sapunov [24].

STRATIGRAPHY. The base of the zone is defined by the appearance of *Pleydellia*, whilst the upper limit is drawn by the extinction of the genus and the incoming of the first *Leioceras* into the bottom of the Aalenian. Several genera of dominantly Aalenian occurrences have been recently found to appear into the upper part of the zone. These are *Czernyeiceras*, *Bredyia* and *Pseudammatoceras* [37, 39]. Like the *D. pseudoradiosa* Zone from above, this zone corresponds exclusively to the distribution of its defining genus, and ammonites of only two other genera were recorded: *Osperleioceras* and *Pseudolioceras* [35, 38]. The occurrence of *Pleydellia* within the zone seem to represents an evolutionary trend of gradual morphological change from evolute and costulate species to moderately evolute striate examples [38]. Such development has been found to be in accordance with the successions described in South-eastern France by RULLEAU et al. [72]. It was confirmed from all localities into which the zonal association has been separated. For this reason the zone is understood to be an equivalent of the Aalensis Zone from the current scale of Elmi et al. [45] (Fig. 2). The possibility for recognition of subzones became aware and two names have recently been initially nominated [39].

The best developments of the *P. aalensis* Zone throughout the Balkan Mts Area approximately repeat those of the *D. pseudoradiosa* Zone as sections and thicknesses as given above.

The subdivision of the zone into subzones follows the general application taken from many localities in Europe. It has been done in confirmation that two stages of arrangement of the species composing the total range of *Pleydellia* exist. It was evidenced that species having a fine and dense ornament and rounded elliptical whorls are more common in the lower part of the zone. This morphology seems to be of ancestral origin, probably derived from the *Dumortieria* lineage from below. That was initially noticed by Buckman [59] who founded the genus *Cotteswoldia* on such record from the Inferior Oolite Series in Britain. There is a general agreement at the present that Buckman's name should be retained in employment but under a subgeneric status of the genus *Pleydellia*. It reflects the first stage of development of the genus in its time-span. The same situation exists with another name also proposed by Buckman, that of the genus *Walkericeras*. It

has been given for some members of the zonal association of the *P. aalensis* Zone, having stronger ribbing, flattened whorls, flat and sloping umbilical walls, which distribution overlaps upwards that of *Pleydellia (Cotteswoldia)*. There is consent again that it is reasonable to use it as subgeneric name which exhibits evolutionary changes of *Pleydellia* lineage happened to the late phase of development of the genus.

Another sequence of species subsists throughout the zone covering both *Pleydellia (Cotteswoldia)* and *Pleydellia (Walkericeras)* occurrences. It is represented by the index species of the zone and several allied taxa having an intermediate morphology. There is no decision up to the present, but it seems that this series needs to be stabilized in terms of a nominate subgenus of genus *Pleydellia*.

Pleydellia mactra Subzone

Index species. *Pleydellia mactra* (Dumortier, 1874). According to Rulleau [73], the specimen which was figured by Dumortier (1974, pl. 50, Figs 4, 5) [58] is lost. The type collection on which the species was introduced is found to contain many ammonites, but most of them related to other taxa of genus *Pleydellia* as well as to the Aalenian *Leioceras*. Two specimens, however, have been found to belong to *Pleydellia mactra*, and one of them was designated neotype and figured (Rulleau, 1998, p. 109, Pl. 17, fig. 1) [73]. The index species has never been figured in Bulgaria before. One ammonite from the Boukorovtsi Member of the Ozirovo Formation was misidentified as *P. mactra* (Dumortier) by Metodiev (1997, Pl. 4, Fig. 9) [32]. In this paper a small negative from the Ozirovo Formation at the section near the village of Beledie Han is figured (Fig. 6t).

Nomenclature. The subzone was defined at first by Gabilly et al. [54]. In this sense, it takes a part of the current scale of Elmi et al. [45]. This study applies first the subzone in Bulgaria in much the same manner.

Stratigraphy. The subzone has been found to contain the record of the several species represented in rising order as follows:

Pleydellia (Cotteswoldia) paucicostata Buckman) (Fig. 6x);

Pleydellia subcompta (Branco) (Fig. 6r), *Pleydellia (Cotteswoldia) egena* Buckman (Fig. 6s);

Pleydellia (Cotteswoldia) aff. *hinsbergi* (Benecke), *P. (C.) grandjeani* (Benecke) [38];

Pleydellia (Cotteswoldia) aff. *attrita* Buckman (Fig. 6u), *P. (C.) bifax* Buckman (Fig. 6z), *P.(C.) subcandida* Buckman, and *P. (C.) limatila* Buckman [38];

Pleydellia mactra (Dumortier) (Fig. 6t).

Pleydellia aalensis Subzone

Index species and Nomenclature. See *P. aalensis* Zone. The name of the subzone has changed into the current scale of scale of Elmi et al. [45], and the recently proposed *Pleydellia (Walkericeras) lugdunensis* Elmi & Rulleau came into use as index species (Fig. 2). Later was interpreted to be separate species with higher position and morphology which is distinct from that of *Pleydellia aalensis*

sensu stricto. In this study the preference was given to the classical species to be used as index because of the sudden occurrence of *P. (W.) lugdunensis* into Bulgarian localities.

Stratigraphy. The subzone is defined by the occurrence of the following main species and associates, arranged in ascending order:

Bredyia alleoni (Dumortier), *Czernyeiceras* sp.;

Pleydellia buckmani Maubeuge (Fig. 6y);

Pseudammatoceras cf. *subinsigne* (Oppel) [38], *Pseudolioceras beyrichi* (Schloenbach) [39];

Pleydellia (Walkericeras) superba Buckman, *P. (W.)* cf. *burtonensis* Buckman [38];

Pleydellia leura Buckman (Fig. 6w);

Pleydellia (Walkericeras) aff. *lugdunensis* Elmi & Rulleau (Fig. 6v);

Pleydellia aalensis (Zieten) (Fig. 6q), *Pleydellia dudelangensis* Maubeuge [32];

Acknowledgements. This analysis of biostratigraphy of the Toarcian ammonites in Bulgaria benefited greatly from many discussions over the years with Prof. Sapunov who generously loaned his material to be entirely available. The colleagues from the Museum of Palaeontology at the University of Sofia (Bulgaria), and especially the head of the Department of Geology and Palaeontology Assoc. Prof. Dr. Marin Ivanov, are acknowledged with pleasure for access to specimens in the collections in their care. Special thanks are due to many people for their help during the field works and for logistic support: Mrs. and Mr. Margarita and Emil Filipovi (Gorno Ozirovo), Mrs. and Mr. Vassilka and Luben Ilievi (Kostinbrod), Mrs. and Mr. Ivanka and Georgi Chervenkovi (Teteven), Mr. Doncho Petrov (Cherni Osum), Mrs. and Mr. Velichka and Georgi Radulovi (Troyan), Dr. Alexander Radulov, Dr. Milena Georgieva, Dr. Rossitsa Vassileva, Ms. Daniela Stoyanova, Mr. Iliya Dimitrov, Mr. Zlati Zlatev. Dr. Louis Rulleau (Lyon) bows author's acknowledgements for fruitful discussions on the Toarcian ammonite record from Bulgaria. Mr. Stoyan Boev is thanked for the pre-press of figures.

REFERENCES

[1] Toula F. Denksch. d. k. Akad. Wissensch., mathem.-naturwissensch., Cl. **44**, 1881, 1–56, pls 1–4.

[2] Toula F. Denksch. d. k. Akad. Wissensch., mathem.-naturwissensch., Cl. **55**, 1889, 1–108, pls 1–9.

[3] Toula F. Sitzb. k. Akad. Wissensch., **102**, 1893, No 1, 191–206.

[4] Zlatarski G. N. Ann. Univ. Sofia, **3**, 1908, 149–228 (in Bulgarian with French summary).

[5] Oppel A. Die Juraformatien Englands, Franckreich und des südwestlichen Deutschlands. Nach ihren einselen Gliedern eingeteilt und ferlichen. Stuttgart, 1–3, 1856–1857, 857 pp.
[6] Bončev E., V. Tzankov. Bull. Bulg. Geol. Soc., **7**, 1935, No 1, 15–23, 1 pl. (in Bulgarian with German summary).
[7] Koen E. R. Bull. Bulg. Geol. Soc., **3**, 1931, No 1, 15–96, 5 pls (in Bulgarian with German summary).
[8] Kamenov B. Bull. Bulg. Geol. Soc., **8,** 1936, No 2, 135 pp., 7 pls (in Bulgarian with French summary).
[9] Mandev P. Bull. Bulg. Geol. Soc., **13**, 1936, No 1, 1–70, pls 1–6 (in Bulgarian with French summary).
[10] Koen E. R. Le Mésozoïque dans la Bulgarie. In: Géologie de la Bulgarie. Ann. Dir. Rech. Géol. et Min. Bulg., **4**, 1946, 105–168, pls 3–10 (in Bulgarian with French summary).
[11] Atanasov A. Bull. Bulg. Geol. Soc., **20**, 1950, No 2–3, 183–248 (in Bulgarian with French summary).
[12] Atanasov G. Bull. Inst. Géol., Acad. Bulg. Sci., **2**, 1953, 145–189 (in Bulgarian with Russian and French summaries).
[13] Kerekov S. J. Ann. Univ. Sofia, Fac. Biol., Géol. et Géogr., **47**, 1953, No 2, 55–108 (in Bulgarian with German summary).
[14] Sapunov I. G. Trav. géol. Bulg., **1**, 1959, 17–49, pls 1–4 (in Bulgarian with Russian and English summaries).
[15] Nachev I. Ann. Dir. Rech. Géol. et Min. Bulg., sér. A, **7**, 1957, 179–218 (in Bulgarian with Russian and German summaries).
[16] Nachev I. Bull. Geol. Inst., **8**, 1960, 47–103, pls 1–5 (in Bulgarian with Russian and English summaries).
[17] Encheva M. Ann. Dir. Rech. Géol. et Min. Bulg., sér. A, **9**, 1960, 87–125, pls 1–9 (in Bulgarian with Russian and German summaries).
[18] Sapunov I., I. Nachev. Trav. géol. Bulg., sér. Paléont., **1**, 1959, 51–73, pls 1–10 (in Bulgarian with English and Russian summaries).
[19] Nachev I., I. Sapunov, J. Stephanov. Bull. Bulg. Geol. Soc., **22**, 1961, No 2, 205–216 (in Bulgarian with Russian and English summaries).
[20] Nachev I., I. Sapunov, J. Stephanov. Trav. géol. Bulg., sér. stratigr. et tect., **4**, 1962, 51–60 (in Bulgarian with Russian and English summaries).
[21] Nachev I., I. Sapunov, J. Stephanov. Trav. géol. Bulg., sér. stratigr. et tect., **5**, 1963, 99–146 (in Bulgarian with Russian and English summaries).
[22] Sapunov I. Trav. géol. Bulg., sér. stratigr. et tect., **3**, 1961, 93–137 (in Bulgarian with Russian and English summaries).
[23] Sapunov I. Trav. géol. Bulg., sér. paléont., **5**, 1963, 109–147, pls 1–6 (in Bulgarian with Russian and English summaries).
[24] Sapunov I. Bull. Geol. Inst., ser. paleont., **17**, 1968, 133–165, pls 1–3 (in Bulgarian with Russian and English summaries).
[25] Dean W. T., D. T. Donovan, M. K. Howarth. Bull. Brit. Mus. (Nat. Hist.), geol., **4**, 1961, No 10, 435–505, pls 63–75.
[26] Sapunov I. Compt. rend. Acad. bulg. Sci., **22**, 1969, No 7, 807–810.
[27] Sapunov I., P. Tchoumatchenco, V. Shopov. Bull. Geol. Inst., ser. geotect., stratigr. and lithol., **16**, 1967, 125–143 (in Bulgarian with Russian and English summary).

[28] Sapunov I., P. Tchoumatchenco, V. Shopov. Ann. Univ. Sofia, Fac. Géol. et Géogr., **67**, 1976, No 1, 101–149 (in Bulgarian with French summary).
[29] Sapunov I., P. Tchoumatchenco, V. Shopov. Geologica Balc., **24-2**, 1994, 3–19.
[30] Sapunov I., P. Tchoumatchenco, V. Shopov. Geologica Balc., **26-3**, 1996, 3–19.
[31] Sapunov I., P. Tchoumatchenco. 2nd International Symposium on Jurassic Stratigraphy, Lisbon, 1988, 699–715.
[32] Metodiev L. Geologica Balc., **27**, 1997, No 3–4, 3–31, 6 pls.
[33] Metodiev L. Geologica Balc., **32**, 2002, No 2–4, 165–189, 6 pls.
[34] Metodiev L. Compt. rend. Acad. bulg. Sci., **56**, 2003, No 10, 69–74, 1 pl.
[35] Metodiev L. Compt. rend. Acad. bulg. Sci., **59**, 2006, No 4, 767–774.
[36] Metodiev L. Geologica Balc., **33**, 2003, No 1–2, 110.
[37] Metodiev L., I. Sapunov. Geologica Balc., **29**, 1999, No 3–4, 41–50, 1 pl.
[38] Metodiev L., E. Koleva-Rekalova, D. Ivanova. Compt. rend. Acad. bulg. Sci., **58**, 2005, No 1, 39–46.
[39] Metodiev L. Volumina Jurassica, **4**, 2006, 186–188.
[40] Čatalov G. Geologica Balc., ser. operum singulorum, **4**, 1990, 271 pp., 41 pls (in Bulgarian with Russian and English summaries).
[41] Sapunov I., P. Tchoumatchenco, P. Mitov. Geologica Balc., **18**, 1988, No 1, 3–82 (in Russian with English and Russian abstracts).
[42] Bassoulet J. P., S. Elmi, A. Poisson, L.-E. Ricou, F. Cecca, Y. Bellion, R. Guiraud, F. Baudin. In: Atlas Tethys – Palaeoenvironmental Maps. Gauthier-Villars, Paris, 1993, 63–80.
[43] Fourcade E., J. Azéma, J. P. Bassoulet, F. Cecca, J. Dercourt. In: The Ocean Basins and Margins, **8**; The Tethys Ocean. Plenum Press, New York, 1995, 191–214.
[44] Sapunov I. Mém. B. R. G. M., Fr., **75**, 1974, 263–270.
[45] Elmi S., L. Rulleau, J. Gabilly, R. Mouterde. In: GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE. Bull. Centre Rech. Elf Explor. Prod. (Cariou, E., Hantzpergue, P., coord.), **17**, 1997, 25–36, Table 4.
[46] Buckman S. S. Quart. J. Geol. Soc. London, **66**, 1910, 52–89.
[47] Howarth M. K. Bull. Brit. Mus. (Nat. Hist.), geol., **24**, 1973, No 4, 238–275, 9 pls.
[48] Buckman S. S. Yorkshire Type Ammonites. London & Thame, 1–7, 1909–1930, 783 pls.
[49] Sapunov I., J. Stephanov. Colloque du Jurassique, Luxembourg, 1962, Vol. C. R. et Mém., 1962, 705–718.
[50] Howarth M. K. Monograph of the Palaeontographical Society, London, 1–2, 1992, 200 pp., 38 pls.
[51] Sowerby J. The Mineral Conchology of Great Britain or coloured figures and descriptions of those remains of testaceous animals or shells, which have been preserved at various times and depths in the earth. London, 1–7, 1812–1846, 648 pls.
[52] Reynès P. Essai de géologie et de paléontologie aveyronnaises, 1868, 110 pp, 6 pls.
[53] Haug E. N. Jb. Min. Geol., Stuttgart, **3**, 1885, 585–722, pls 11, 12.
[54] Gabilly J., S. Mattei, R. Mouterde. Mém. Soc. Géol. Fr., **2**, 1971, 82–94.
[55] Meister E. Zeit. Deut. Geol. Ges., **65**, 1913, 518–586, pls 12–14.
[56] Fucini A. Palaeontographia Italica, **25**, 1922, 173–192, pl. 16.
[57] Merla G. Palaeontographia Italica, **33**, 1933, nov. ser., 3, 1–54, 8 pls.

[58] Dumortier E. In: Etudes paléontologiques des dépôts jurassiques du Bassin du Rhône. Savy, Paris, No 4, 1874, 335 pp., 62 pls.
[59] Buckman S. S. Monograph of the Palaeontographical Society, London, 1887–1907, 40–53, 456 pp., 103 pls, 242 suppl. pp., 24 suppl. pls.
[60] Fischer J.-C. Révision critique de la Paléontologie Française d'Alcide d'Orbigny, incluant la réédition de l'original. Vol. **I**. Céphalopodes Jurassiques. Masson, Paris, Milan, Barcelone, 1994, 340 pp., 90 pls.
[61] d'Orbigny A. Paléontologie Française. Terrains oolitiques ou jurassiques. I. Céphalopodes. Paris, 1842–1851, 642 pp.
[62] Rulleau L. Géobios. M. S., **15**, 1993, 331–339.
[63] Denckmann A. Abh. Geol. Spezialk. Preuss. Thür. Staaten, Berlin, **8**, 1887, No 2, 108 pp., 10 pls.
[64] Gabilly J. Mém. Soc. Géol. Fr., N. S., **124**, 1975, 1–196, 36 pls, 133 figs.
[65] García-Gómes G., P. Rivas. Estudios geol., **36**, 1980, 263–274, 3 pls.
[66] Bayle E. In: Explications de la carte géologique de France. Paris, 4, 1878, 148 pls.
[67] Gabilly J. Mém. B. R. G. M., **4**, 1961, 345–356.
[68] Branco W. In: Abhandlungen zur geologische Specialkarte Elsass – Lothringen. Strasbourg, **2**, 1879, No 1, 160 pp., 10 pls.
[69] Spath L. F. Geol. Magazine, London, **79**, 1942, 264–268.
[70] Mouterde R. Bull. Carte géol. Fr., **50**, 1953, 63–521, 40 figs, 7 tables.
[71] Zieten C. H. von. Die Versteinerungen Württembergs, Stuttgart, 1830–1833, 102 pp., 72 pls.
[72] Rulleau L., S. Elmi, B. Thévenard. Docum. Lab. Géol. Lyon, **154**, 2001, 153 pp., 24 figs, 31 pls.
[73] Rulleau L. Mém. Mus. Hist. nat. Lyon., **2**, 1998, 208 pp.

Geological Institute
Bulgarian Academy of Sciences
Acad. G. Bonchev Str., Bl. 24
1113 Sofia, Bulgaria
e-mail: lubo@geology.bas.bg