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The present volume compiles short papers with new data on the Jurassic-Cretaceous boundary strata and their fauna of different regions of Russia (Volga region, Siberia, Crimea, Primorye) and of North America. Most papers are devoted to problems of biostratigraphy and paleontology of marine animals and their trace fossils. Besides this, some data on magnetostratigraphy, interregional correlations, history of defining J/K boundary in the Decisions of ISC, and eoomic value of the interval.

For geologists, paleontologists, stratigraphers, students of geological and geographical profiles.

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В сборнике опубликованы новые данные о пограничных отложениях юры и мела различных регионов России (Поволжье, Сибирь, Крым, Приморье) и Северной Америки. Большинство работ посвящено биостратиграфии и палеонтологии морских животных и следов их жизнедеятельности. Кроме того, приводятся сведения о магнитостратиграфии, межрегиональной корреляции, истории проведения границы юры и мела в постановлениях МСК, и экономической важности этого интервала.

Сборник представляет интерес для геологов, палеонтологов, стратиграфов, студентов геологического и географического факультетов.

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BELEMNITES AND BIVALVES FROM THE JURASSIC-CRETACEOUS BOUNDARY INTERVAL OF THE KASHPIR SECTION, MIDDLE VOLGA BASIN, RUSSIA: IMPLICATIONS FOR BIOSTRATIGRAPHY AND PANBOREAL CORRELATION

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***Abstract**: Abundant belemnites and bivalves from the Middle Volgian–Ryazanian of the Kashpir section (Middle Volga Basin, Russia) were studied. Belemnite assemblages are typically Subboreal. Here, from the base upwards, the following biostratigraphic units based on belemnites were recognized: Lagonibelus magnificus Beds, Eulagonibelus rosanovi Beds, E. volgensis Beds, Liobelus russiensis & Acroteuthis mosquensis Beds, Liobelus lateralis Beds, and Acroteuthis explanatoides Beds. The studied bivalve assemblages are mainly represented by both typically Boreal and Subboreal forms. The following beds and zones based on Buchia are established in the Kashpir section: B. russiensis-mosquensis Beds, B. terebratuloides Zone, B. obliqua Zone, B. unschensis Zone, B. volgensis Zone, B. okensis Zone, B. jasikovi Zone, and B. tolmatschowi Zone. In general, the above-mentioned buchiid succession repeats that of the Boreal standard. A brief review is presented of belemnite and buchiid zonations in the Kashpir section and their application to successions in other Boreal regions.*

***Key words:** belemnites; bivalves; Volgian; Ryazanian; Central Russia; biostratigraphy*

In the late XIX century, the Volgian to Valanginian succession at Kashpir (nearby Syzran town) has already attracted the attention of paleontologists. The first description of the section was provided by R. Pakht in 1856. The description was specified subsequently by G.A. Trautschold, I.I. Lahusen, N.P. Vishnyakov and A.P. Pavlow. The Kashpir section was studied in a series of exposures at the right bank of the Volga River as well as along the walls of gullies. Detailed lithological and paleontological characteristics of this section were provided by I.G. Sasonova & N.T. Sasonov [15] and P.A. Gerasimov [6]. In a subsequent period, lithology and paleontology (ammonites, belemnites, bivalves, etc.) were subjected to repeated revisions [1, 2, 8, 16], and special attention was paid to palynological studies [9, 12, 13]. K. Kessels et al. [10] have reported calcareous nannofossils from the Volgian of the Kashpir section, whereas D.V. Efimov [5] has studied Volgian ichthyosaurs. E.A. Molostovsky & V.N. Eremin [11] have proposed a magnetostratigraphic column for the Upper Volgian, but detailed paleomagnetic and rock magnetic data are not presented in the work. O- and C-isotope data have been collected mainly from the Ryazanian of the Kashpir section [7].

In 2013, the 10 m thick Jurassic–Cretaceous boundary section (Middle Volgian to Ryazanian) was studied by the authors at several points: a) Volga River bank, to the south of the Novokashpirskii Boat Station (NK-1); b) Novokashpirskii oil shale mine (NK-2); c) Kashpirovka gully, right bank near Kashpir village (K-1); d) Volga River bank, near the mouth of the Kashpirovka Brook (K-2) (**Fig. 1**). Preliminary results from this study were published in 2014 [18]. The most representative section of the Volgian and Ryazanian stages (NK-1) is exposed along the bank slopes of the Volga River near Novokashpirskii village; the outcrop was identified here along a ~900 m stretch of

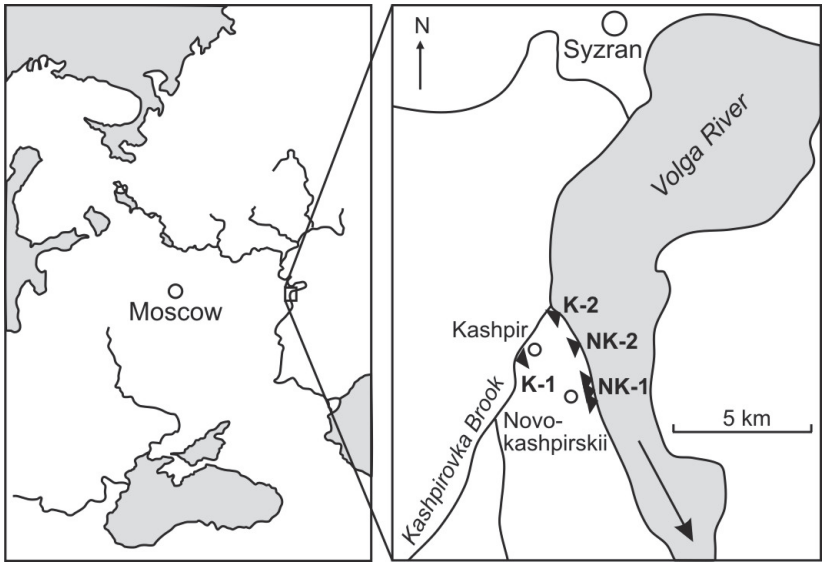


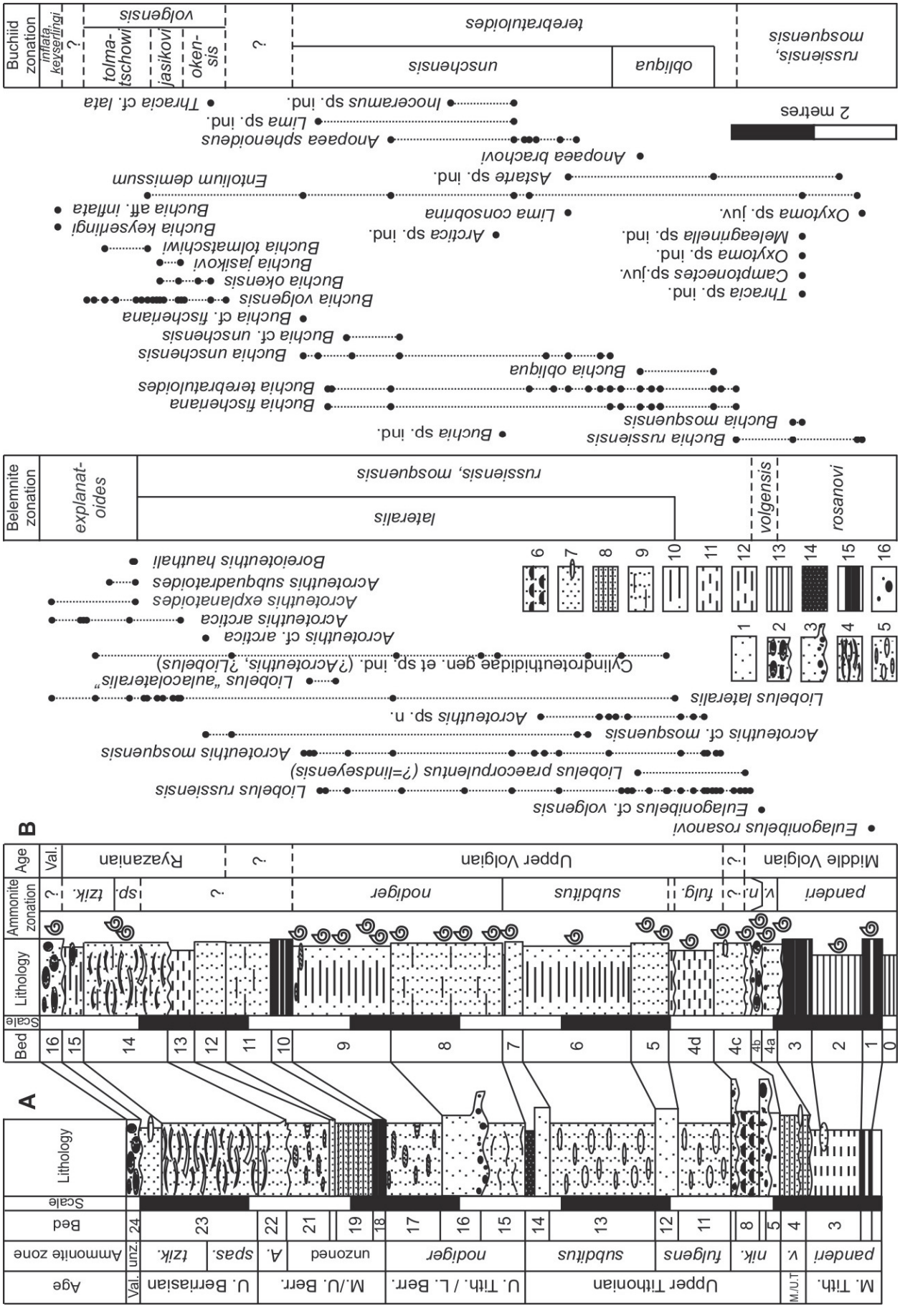
Fig. 1. Location of studied sections: NK-1 – Volga River bank, to the south of the Novokashpirskii Boat Station; NK-2 – Novokashpirskii oil shale mine; K-1 – Kashpirovka gully, right bank near Kashpir village; K-2 – Volga River bank, near the mouth of the Kashpirovka Brook.

the river with almost no interruption.

In the outcrop NK-1, the Volgian–Ryazanian succession is subdivided by us into 16 beds, which have a good correlation with lithological column constructed by Harding et al. [9] (**Fig. 2**). The section is extremely rich in fossils, including ammonites, belemnites and bivalves. However, the Volgian–Ryazanian boundary interval (beds 10 and 11) is not characterised by macrofossils with the exception of poorly preserved belemnites at the top of the bed 11. Hence, the definition of precise position of the Volgian–Ryazanian boundary in the Kashpir section is rather problematic.

The Volgian Stage in the outcrop NK-1 is well characterised by ammonites of the Dorsoplanites panderi Zone to the Craspedites nodiger Zone. The investigation of ammonites revealed that FADs (first appearance datum) of two zonal index species, *Kachpurites fulgens* and *Craspedites subditus*, are lower than it was supposed earlier [9]. The FAD of *K. fulgens* has been fixed by us at the top of the bed 4c (=bed 9 in [9]), and the FAD of *C. subditus* has been fixed in the bed 5 (=bed 12 in [9]), exactly at its base. Two ammonite zones are commonly recognised in the Ryazanian of the Kashpir section: Surites spasskensis Zone (or the uppermost part of the Riasanites rjasanensis Zone in some publications) and S. tzikwinianus Zone [1, 2, 9]. We found *S. spasskensis* (bed 14, 40 cm above the bottom) and *S.* cf. *subtzikwinianus* (bed 14, 50 cm above the bottom).

Belemnites (Cylindroteuthididae) in the Kashpir section are of great abundance but generally poorly diversified. Their assemblages consist mainly of Subboreal representatives of the genera *Lagonibelus, Eulagonibelus, Liobelus,* and *Acroteuthis*.


A
B
Age
Ammonite zone
Bed
Scale
Lithology
M. Tith.
Upper Tithonian
U. Tith. / L. Berr.
M./U. Berr.
U. Berriasian
Val.
panderi
nik.
fulgens
subditus
nodiger
unzoned
spas.
tzik.
Middle Volgian
Upper Volgian
Ryazanian
Eulagonibelus rosanovi
Eulagonibelus cf. volgensis
Lobelus russiensis
Lobelus praecorpulentus (?=lindseyensis)
Acroteuthis mosquensis
Acroteuthis cf. mosquensis
Acroteuthis sp. n.
Lobelus lateralis
Lobelus "aulacolateralis"
Cylindroteuthididae gen. et sp. ind. (?Acroteuthis, ?Lobelus)
Acroteuthis cf. arctica
Acroteuthis arctica
Acroteuthis explanatoides
Acroteuthis subquadratoides
Borioteuthis hauthali
Belemnite zonation
explanat-oides
lateralis
russiensis, mosquensis
volgensis
rosanovi
Buchia russiensis
Buchia mosquensis
Buchia sp. ind.
Buchia fischeriana
Buchia terebratuloides
Buchia oblíqua
Buchia uncshensis
Buchia cf. uncshensis
Buchia cf. fischeriana
Buchia volgensis
Buchia okensis
Buchia jasikovi
Buchia tolmatschiwi
Buchia keyserlingi
Buchia aff. inflata
Entolium demissum
Astarte sp. ind.
Anopaea brachovi
Anopaea sphenoideus
Lima sp. ind.
Inoceramus sp. ind.
Thracia cf. lata
Thracia sp. ind.
Camptonectes sp.juv.
Oxytoma sp. ind.
Meleagrinella sp. ind.
Oxytoma sp. juv.
Lima consobrina
Arctica sp. ind.
2 metres
Buchild zonation
russiensis, mosquensis
oblíqua
uncshensis
terebratuloides
?
okensis
jasikovi
tolmatschowi
volgensis
inflata, keyserlingi

The study of new collection from the Kashpir section has allowed to obtain accurate information about stratigraphic range of belemnite species and for the first time to establish here the following regional biostratigraphic units: *Eulagonibelus volgensis* Beds (4a–4b beds transition), *Liobelus russiensis* & *Acroteuthis mosquensis* Beds (bed 4c – lower part of the bed 14), *Liobelus lateralis* Beds (top of the bed 4d – lower part of the bed 14), and *Acroteuthis explanatoides* Beds (upper part of the bed 14 and above). In addition, the allocation of the *Eulagonibelus rosanovi* Beds is suggested for the topmost Dorsoplanites panderi ammonite Zone (beds 1–3). The lowermost layers of the Middle Volgian D. panderi Zone were established by excavation on the Kashpirovka Brook where the index species of the regional *Lagonibelus magnificus* belemnite Beds was found. The topmost Middle Volgian (Epivirgatites nikitini ammonite Zone), Upper Volgian and Ryazanian are characterised almost entirely by representatives of the genera *Acroteuthis* and *Liobelus*. Only rare *Boreioteuthis* have been found in the upper part of the Ryazanian. In the Ryazanian, the remarkable change in belemnite assemblages is observed in the middle part of the bed 13 and especially in the bed 14: several species make their first appearance in the section (*Acroteuthis arctica, A. explanatoides, A. subquadratoides, Boreioteuthis hauthali*).

Almost all belemnite units determined in the Kashpir section can be traced in NW Europe, namely *Lagonibelus magnificus* Beds, *Eulagonibelus volgensis* Beds, *Liobelus russiensis* & *Acroteuthis mosquensis* Beds, *Liobelus lateralis* Beds, and *Acroteuthis explanatoides* Beds [3, 4]. West and East European belemnite scales considerably differ from Siberian ones in the interval from the upper half of Volgian to the Ryazanian that is directly connected with peculiarities of development of Boreal-Atlantic and Arctic biogeographic realms [3].

The study of bivalves collected in the Kashpir section showed that *Buchia russiensis* and *B. mosquensis* are numerous in the lower part of the section (bed 1 – middle part of the bed 4c). These two species are characteristic of the Middle Volgian Buchia mosquensis Zone. Representatives of the genera *Oxytoma, Astarte, Entolium, Thracia, Camptonectes* and *Meleagrinella* have been found here together with buchiids. A change in the *Buchia* assemblages is fixed in the middle part of the bed 4c, where *B. terebratuloides* and *B. fischeriana*, characteristic of the Upper Volgian B. obliqua Zone, appear in the section. However, *B. obliqua* occurs only in the bed 4d. The bivalve assemblage also contains *Astarte* and *Anopaea*. In the beds 6–9, the *Buchia* assemblage typical for the B. unschensis Zone is found. Here, *B. terebratuloides, B. fischeriana* and the index species are accompanied by *Entolium, Lima, Arctica, Anopaea*, etc.

Numerous buchiids, which assemblage is characteristic for the Buchia okensis Zone, are found within the bed 12. Only few *B. volgensis* are recorded from the bottom of this bed (see **Fig. 2**), whereas numerous *B. okensis* and *B. volgensis* are found a

Fig. 2. Jurassic-Cretaceous boundary strata of the Kashpir section: A, according to Harding et al. [9]; B, present paper. Lithology: 1 – sandstone; 2 – sandstone with phosphatic concretions; 3 – sandstone with conglomerate base; 4 – sandstone with shelly hash; 5 – lenticular-bedded sandstone; 6 – phosphoritic sandstone; 7 – sandstone with carbonate concretions; 8 – laminated sandstone; 9 – silty sandstone; 10 – sandy siltstone; 11 – siltstone; 12 – clayey siltstone; 13 – mudstone; 14 – dark grey calcareous mudstone; 15 – bituminous shale; 16 – pebble.

little above. Therefore, the bed 12 undoubtedly belongs to the Ryazanian. Respectively the beds 10 and 11 (i.e., the beds lacking macrofossils) can belong to the top part of the B. unschensis Zone. In overlying part of the section (beds 13 and 14), the index species of the B. jasikovi and B. tolmatschowi zones are found. The bivalve assemblage of the bed 15 is not identified. Typical Valanginian bivalves, *B. keyserlingi* and *B.* aff. *inflata*, are found in the bed 16.

Thus, a buchiid zonation, characteristic of the Jurassic–Cretaceous boundary interval of Boreal sections, is observed at the Kashpir section. It is noteworthy that the FAD of *Buchia terebratuloides* is commonly fixed at the base of the Upper Volgian in Siberian sections, together with the FAD of *B. obliqua*. However, in the Kashpir section, the first representatives of *B. terebratuloides* appear slightly earlier than *B. obliqua*. The similar case was previously described by V.A. Zakharov [19] for the Boyarka River section (Eastern Siberia), where the FAD of *B. terebratuloides* was also recorded below than the FAD of *B. obliqua*, i.e. below the base of the Craspedites okensis ammonite Zone. The lower boundary of the Buchia unschensis Zone in the Kashpir section also does not correspond to that in the Boreal standard [17, 20]. Representatives of *B. unschensis* appear in the middle part of the Craspedites subditus ammonite Zone. The similar situation was described from the East Siberian sections (Boyarka and Lena rivers), where the FAD of *B. unschensis* has been fixed at the top part of Craspedites okensis ammonite Zone [14, 19].

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