

# Lower Bathonian Belemnites and Biostratigraphy of the Central and Southern Parts of the East European Platform: Part 1. Megateuthididae

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**Abstract**—Belemnites from the lower Bathonian of the Russian Plate are revised on the basis of the study of two reference sections—Pletnyovka and Sokur quarries. The first part of the study deals with the members of the family Megateuthididae. They include eight species of the genus *Barskovisella* gen. nov., neoendemic to the territory of the Russian Plate and originating from high Boreal taxa—species of the genus *Paramegateuthis* Gustomesov, 1960, which immigrated to the Middle Russian Sea in the early Bathonian via a short-lived meridional strait. The new genus includes six new species described in the present paper—*Barskovisella pseudoishmensis* sp. nov., *B. issae* sp. nov., *B. variabilis* sp. nov., *B. barskovi* sp. nov., *B. gracilis* sp. nov., and *B. renegata* sp. nov. The beds with *Barskovisella*, a new belemnite-based unit, corresponding to the *Oraniceras besnosovi* ammonite zone and including four successive phylogenetic biohorizons well comparable in resolution with ammonite-based infrazonal subdivisions, are introduced.

**Keywords:** belemnites, *Barskovisella* gen. nov., lower Bathonian, European Russia, infrazonal stratigraphy

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## INTRODUCTION

Studies of the Jurassic belemnites of East European Platform traditionally focus on the Callovian–Upper Jurassic taxa represented by the Boreal family *Cylindroteuthididae* and by less common Tethyan *Belemnopseidae* (genus *Hibolithes* de Montfort, 1808). These belemnites were discussed in numerous papers and monographs devoted to their classification (Gustomesov, 1964, 1976, 1989; Nikitin, 1969; etc.), paleoecology (Gustomesov, 1961), and stratigraphy (Nalnjajeva, 1986, 1989); they were the basis for a zonal scale (*Unifitsirovannaya*..., 2012; etc.).

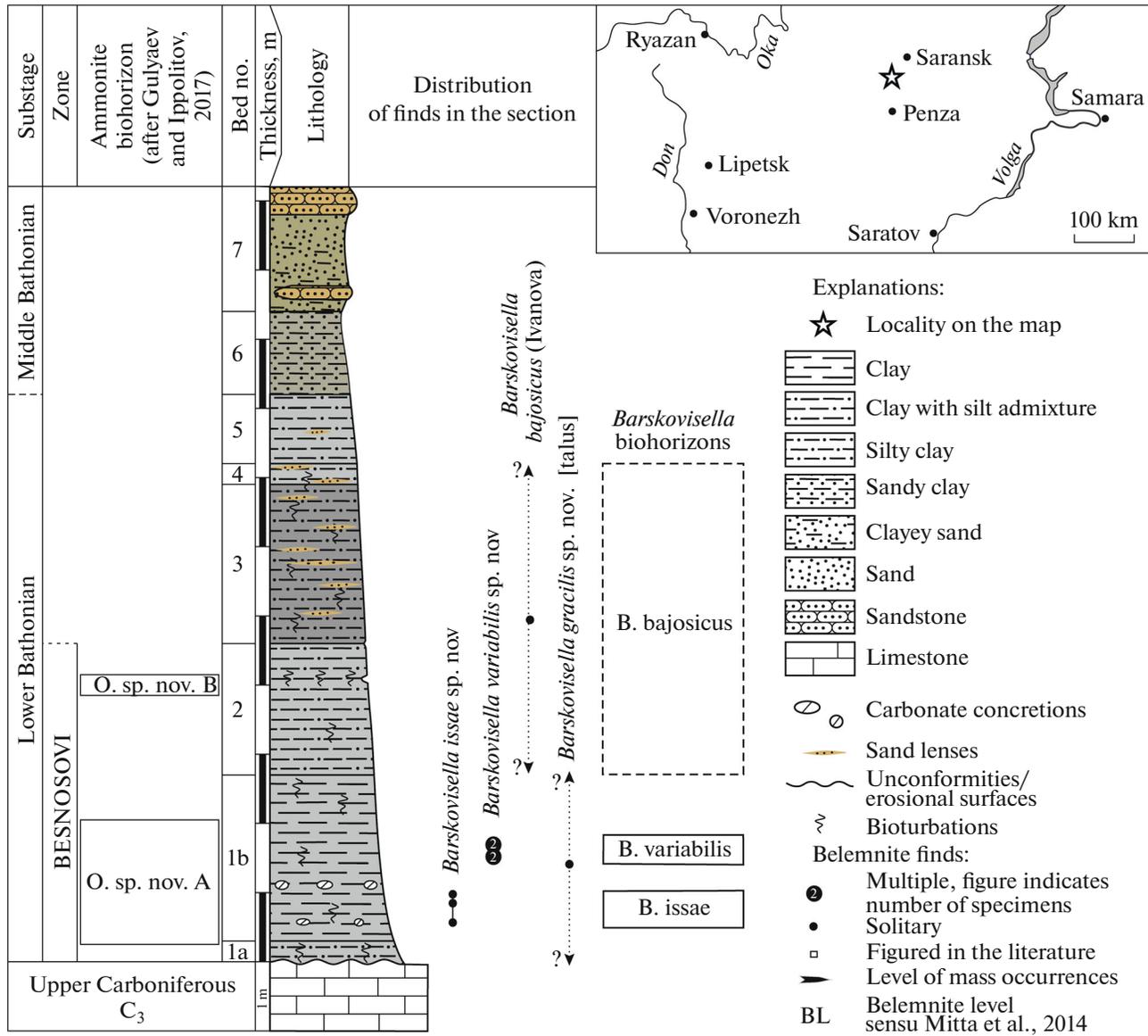
At the same time, belemnites from the earlier Bajocian–early Bathonian deposits, except for the late Bajocian assemblages from the Donets Basin (Borissjak, 1908; Nikitin, 1975, 1981), remain relatively poorly studied. This is a result of poor exposure of rocks of this age in general combined with the scarcity of cephalopods finds in them. In the Volga region, occurrences of pre-Callovian belemnites were mentioned for the first time by Rykov (1951, 1953) from the Volgograd region. Slightly later, Ivanova (1959) described and figured few rostra from the Bajocian–Bathonian in the vicinity of Saratov, identified as *Megateuthis* sp. indet. and *Mesoteuthis bajosicus* A. Ivanova, 1959. Those remained for a long time the only figured specimens from the interval under con-

sideration. However, at the beginning of the 21st century, a series of papers dealing with the fossil assemblages from the Sokur quarry (outskirts of the city of Saratov) were published (Mitta et al., 2004, 2011, 2012, 2014). It has become apparent that the cephalopod fauna of early Bathonian age is highly diverse and contains elements of various paleobiogeographic origins, while the systematic position of some taxa remained debatable.

This paper represents the results of the study of belemnites from the lower Bathonian deposits of the Russian Plate collected in two reference sections—Pletnyovka (Penza region) and Sokur (Saratov) quarries. Much of the material has never been published before and is described here for the first time. This paper is the first part of the investigation providing the revision of the members of the family Megateuthididae, whereas results of the study of the members of the family *Cylindroteuthididae* and other taxa will be published in the second part (Ippolitov, in press).

## LOCALITIES AND MATERIAL

**Pletnyovka quarry** (Fig. 1). The section is located 10 km east of the town of Issa (the northern part of Penza region), north of the villages of Kamenny Brod and Pletnyovka, in the operating Carboniferous limestone quarry of LLC RPA Izvestnyak, and was located



**Fig. 1.** Distribution of the studied belemnite species in the section of the Pletnyovka quarry (Penza region). The section and stratigraphy by ammonites are after Gulyaev and Ippolotov (2017, modified). O.—*Oraniceras*.

by the author in 2016. Jurassic strata are exposed in the overburden. The detailed bed-by-bed description of the section and its ammonite-based stratigraphic subdivision were published previously by Gulyaev and Ippolotov (2017). The fossiliferous part of the succession belongs to the lower Bathonian *Oraniceras besnosovi* Zone and represents an interval underlying the exposed part of the Sokur quarry (Gulyaev and Ippolotov, 2017; Gulyaev, in press). Belemnites are only sporadically met within the section and are represented by megateuthidids, except for a single find which will be described in the second part of the study. The distribution of the occurrences across the section and the belemnite biostrata distinguished are shown in Fig. 1.

**Sokur quarry** (Fig. 2). The section is located in a clay pit on the northwestern outskirts of the city of Saratov, north of 4th Trofimovsky Drive, on the right slope of the Elshanka River valley. It was for the first time described by Seltzer (Mitta and Seltzer, 2002) and was repeatedly featured in later publications (Dzyuba et al., 2017; Mitta et al., 2004, 2011, 2012, 2014; and many others). The quarry is now abandoned and reclaimed, so the fossiliferous part of the succession is inaccessible.

Belemnites from the Sokur quarry identified as “*Megateuthis*” and “*Nannobelus*” were admittedly mentioned for the first time by Seltzer (Mitta and Seltzer, 2002), but the generic identifications of Bathonian belemnites, which are likely to have belonged to

the same locality, were mentioned in earlier works (Seltzer and Ivanov, 1997). Later, belemnites from the Sokur quarry were studied and discussed by various authors, including I.S. Barskov (in Mitta et al., 2004, 2011), T.I. Nalnjaeva (Meledina et al., 2009), and O.S. Dzyuba (Mitta et al., 2012, 2014). Even an early paper by Mitta et al. (2004) showed that the belemnite assemblage from the lower Bathonian of the Russian Plate is characterized by a high morphological and taxonomic diversity (two or three families, several genera) and contains endemics which are difficult to compare with known synchronous taxa. Later, the specific and generic affinity of belemnites from the Sokur quarry caused lively discussion among specialists who proposed their own re-identifications (see a review in Mitta et al., 2014, Table 1). Noteworthy is the fact that the cephalopod assemblage of the Sokur quarry contains taxa of Tethyan (ammonite family Parkinsoniidae), Boreal (ammonite subfamily Arctocephalitinae, belemnite family Cylindroteuthididae), and uncertain (“*Nannobelus*” spp. sensu Mitta et al., 2004) affinities, while the Boreal cephalopods are encountered beginning from the very base of the section of the pit. In other words, the whole lower Bathonian succession exposed in the Sokur quarry corresponds to an episode of geological history when a meridional marine strait across the Russian Plate was opened, connecting Tethys with the Arcto-Boreal area and resulting in the immigration of Boreal cephalopods into the Middle Russian Sea (Seltzer, 2009). In this situation, any forms of doubtful origin could be compared with both Western European and Arctic taxa, which was partly the reason for contradictory taxonomic interpretations.

The author collected material from the Sokur quarry in 2004, 2006, 2013, and 2016. There are significant disagreements about the interpretation of the lithological succession and thicknesses of members between data by Gulyaev (2013; in press) and those in later publications of other authors (Dzyuba et al., 2017; Mitta et al., 2012, 2014). The present study mainly deals with the interval of the succession below the well-recognizable lithological marker—so-called “belemnite level.” This interval is consistently correlated to all published versions of the section log; the members in the present work are numbered according to Mitta et al. (2014).

In addition to my own collections, type and figured specimens of V.A. Gustomesov (1960) and I.S. Barskov (Mitta et al., 2004, 2011), housed in the Vernadsky State Geological Museum (VSGM, Moscow), and those of the classical study by V.N. Sachs and T.I. Nalnjaeva (1975), housed in the Central Siberian Geological Museum (CSGM, Novosibirsk), were examined.

METHODS

To characterize and analyze both the individual rostra and the sets, I used the system of measurements,

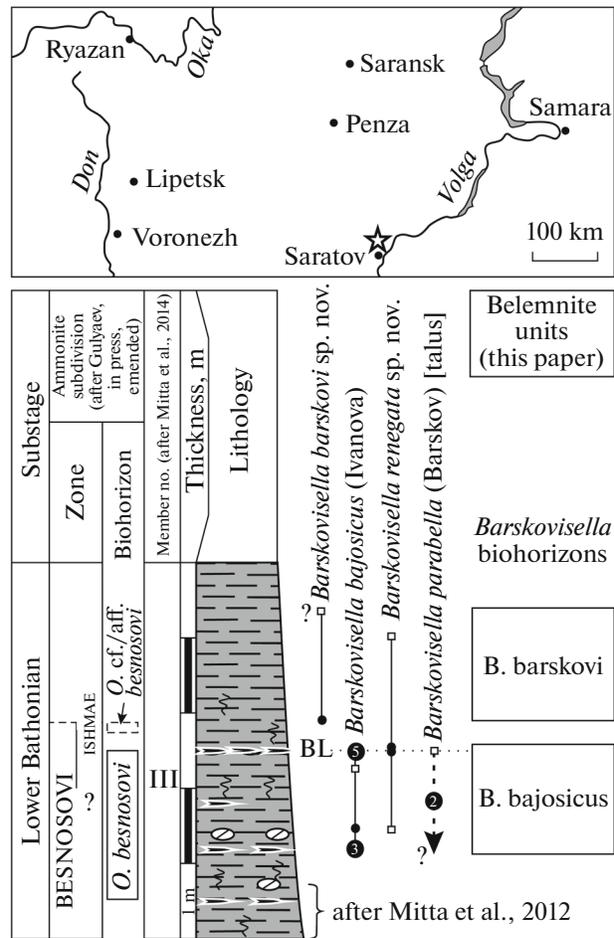


Fig. 2. Distribution of the studied belemnite species in the section of the Sokur quarry (Saratov). The section and stratigraphy by ammonites are after Gulyaev (in press), with emendations. Legend as in Fig. 1. A.—*Arcticoceras*, O.—*Oraniceras*.

ratios, and their abbreviations accepted in the Russian literature for descriptions of the family Cylindroteuthididae (Dzyuba, 2004; Gustomesov, 1964; Sachs and Nalnjaeva, 1964), with some modifications.

**Measurements:** L—total (preserved) length; DV—dorsoventral diameter at the alveolus tip; LL—lateral diameter at the alveolus tip; PA—length of the postalveolar part of the rostrum (“rostrum solidum”; reconstructed in the case of broken apical part); DV’—dorsoventral diameter near the alveolus tip (in an ideal case, this coincides with DV, while the section coincides with that at the tip of the alveolus, but can in fact be located slightly to the front/to the back); R<sub>v</sub>—distance from the apical line to ventral side (ventral radius) near the alveolus tip; β (II)°—alveolar angle in outline; β (dv)°—alveolar angle in profile.

**Ratios:** D = √(DV × LL)—basic diameter at the tip of the alveolus; E = PA/√(DV × LL) × 100%—relative

elongation of the postalveolar part;  $R_v/DV'$ —apical line displacement.

As a main character of the individual size, instead of the traditional dorsoventral diameter (DV), a new parameter was used—basic diameter (D), the calculation of which employs both the dorsoventral (DV) and the lateral (LL) diameters at alveolus tip. This parameter shows more precise correlations with the main ratios than DV, mainly because of its close connection to the sectional area near the protoconch, which, in turn, characterizes the total amount of carbonate matter in this section at the time of the animal's death. Thus, the basic diameter D reflects the individual age of the specimen more accurately than DV, arbitrarily selected as the main parameter by Phillips (1865–1870) and starting from Pavlov (1892) being firmly established in the Russian literature as a principal size character.

The measurements were taken both from available specimens and from photographic images (author's own photographs, where possible; in other cases, published figures were used) and drawings using the CorelDraw software. When measuring photographs, the position of the alveolus tip was fixed using templates, according to which the alveolar angle for *Barskovisella* gen. nov. (from the Sokur quarry) in outline  $\beta$  (II)° was accepted to be 27°. This value corresponds to that observed on my own material of the same age from the same locality. The described procedure was applied only for the rostra in which alveolar margins were well visible on photo. The conventional nature of such kind of estimation of protoconch position, as well as the imprecision of scaling in publications, has a significant effect on the absolute values of measurements, but hardly affects ratios.

The material described below is housed in the Vernadsky State Geological Museum (Moscow).

## RESULTS

The results of the systematic revision of the belemnite family Megateuthididae are represented below. The species level classification proposed in the present study differs significantly from those previously introduced by I.S. Barskov (see Mitta et al., 2004) and O.S. Dzyuba (Mitta et al., 2012, 2014); re-identifications of the specimens cited by the above-mentioned authors are shown in Table 1.

It is necessary to discuss the stratigraphic position of specimens from the Sokur quarry described by I.S. Barskov (Mitta et al., 2004) and considered to be collected from the “belemnite level.” Unlike my own specimens or those figured by O.S. Dzyuba (Mitta et al., 2014), a considerable part of Barskov's specimens do not fit the phylogenetic trends recognized in the present paper. The possible explanation is that some of the belemnite finds do not originate from the “belemnite level,” as claimed by the authors (Mitta et al., 2004), and this

viewpoint is supported by a number of indirect arguments. First, the perfect surface preservation of the holotypes of both “*Nannobelus bellus*” and “*Nannobelus parabellus*” is atypical of the “belemnite level.” In the latter, rostra are usually pyritized in the fresh rock and noticeably ochered when weathered, with their surfaces eroded to some extent. Such preservational characteristics are evident for most specimens of cylindroteuthids from the collection by the same authors. Secondly, the holotype of “*Nannobelus bellus*” is considerably larger in size than any specimen of the type series, which is relatively small itself, and no rostra of similar size were found by subsequent authors. Most likely this indicates that particularly this specimen came from a private collection, like many ammonites (Mitta and Seltzer, 2002; Mitta et al., 2004), and its large size and good state of preservation are explained by a high selectivity. Thirdly, the belemnite collection of Barskov contains specimens with dirty, old broken anterior end (VSGM BP-09664), which is virtually impossible for specimens collected in situ. Fourthly, in later publications (Mitta et al., 2012, 2014), the lithological log was crucially modified, suggesting possible erroneous localization of fossils in earlier papers. In addition, V.B. Seltzer, who was the collector of most specimens described by Barskov, indicates that the belemnite level is “... laterally traced variously in respect to its thickness and fossil content” (pers. comm., 2017). Consequently, material from the “belemnite level” represented by Mitta et al. (2004) should be considered to have been collected from some interval near a certain bedding plane which later (Mitta et al., 2012, 2014) was consistently referred to as “the belemnite level.”

Taking into account the aforesaid, specimens studied by I.S. Barskov (Mitta et al., 2004) are interpreted below as belonging to the “belemnite level” (or to the “upper belemnite level” sensu Mitta et al., 2011) only in cases where this is supported by the state of preservation.

## SYSTEMATIC PALEONTOLOGY

### SUBCLASS COLEOIDEA

#### ORDER BELEMNITIDA VON ZITTEL, 1895

#### FAMILY MEGATEUTHIDIDAE SACHS ET NALNJAIEVA, 1967

##### Genus *Barskovisella* gen. nov.

**E t y m o l o g y.** In honor of Professor I.S. Barskov, head of the Paleontology Department of Moscow State University, who was the first to describe in detail typical representatives of the genus (in Mitta et al., 2004) from the Saratov region. The proposed name consists of a combination of the surname and initials, to avoid homonymy with the Late Devonian conodont *Barskovella* Gatovsky, 2009.

**Type species:** *Barskovisella issae* sp. nov.

**Table 1.** Revised identifications of megateuthiids from the Sokur quarry figured and cited in previous studies (Mitta et al., 2004, 2014)

	No.		Identification as in Mitta et al., 2004, 2014	Figured in	Revised identification
	published	museum			
CR-2790*	VSGM BP-09666		<i>Nannobelus bellus</i> sp. nov.	Mitta et al., 2004, pl. 3, fig. 6	<i>Barskovisella bajosicus</i> (Ivanova)
CR-2792	VSGM BP-09667		"	Mitta et al., 2004, pl. 3, fig. 5	"
CR-2793	VSGM BP-09668		"	Not figured	"
CR-2794	VSGM BP-09669		"	Not figured	"
CR-2791*	VSGM BP-09670		<i>Nannobelus parabellus</i> sp. nov.	Mitta et al., 2004, pl. 3, fig. 7; this paper, Plate III, fig. 1	<i>Barskovisella parabella</i> (Barskov)
CR-2795	VSGM BP-09672		"	Not figured	"
CR-2789	VSGM BP-09671		"	Mitta et al., 2004, pl. 3, fig. 8	<i>Barskovisella barskovi</i> sp. nov.
CR-2785	?		<i>Paramegateuthis</i> cf. <i>pressa</i> Nalnjaeva	Mitta et al., 2004, pl. 3, fig. 2	<i>Barskovisella renegata</i> sp. nov. (?)
CR-2784	?		"	Mitta et al., 2004, pl. 3, fig. 1	"
CR-2804	VSGM BP-09663		"	Not figured	<i>Barskovisella bajosicus</i> (Ivanova)
CR-2803	VSGM BP-09665		"	Not figured	<i>Barskovisella</i> sp. indet. (eroded)
CR-2805	VSGM BP-09664		"	This paper, Plate I, fig. 12	<i>Barskovisella variabilis</i> sp. nov.
CR-2786	VSGM BP-09720		<i>Paramegateuthis</i> cf. <i>manifesta</i> Nalnjaeva	Mitta et al., 2004, pl. 3, fig. 3; this paper, Plate III, fig. 4	<i>Barskovisella parabella</i> (Barskov)
CR-2800	VSGM BP-09682		"	This paper, Plate II, fig. 7	<i>Barskovisella barskovi</i> sp. nov.
CR-2801	VSGM BP-09683		"	Not figured	<i>Barskovisella</i> sp. juv.
CR-2802	VSGM BP-09737		"	Not figured	<i>Barskovisella bajosicus</i> (Ivanova)
CR-2787	VSGM BP-09721		"	Mitta et al., 2004, pl. 3, fig. 4	<i>Barskovisella parabella</i> (Barskov)
	CSGM 265/8		<i>Paramegateuthis parabella</i> (Barskov)	Mitta et al., 2014, fig. 7.8	<i>Barskovisella bajosicus</i> (Ivanova)
	CSGM 265/4		"	Mitta et al., 2014, fig. 7.4	"
	CSGM 265/5		"	Mitta et al., 2014, fig. 7.5	<i>Barskovisella barskovi</i> sp. nov.
	CSGM 265/6		<i>Paramegateuthis bella</i> (Barskov)	Mitta et al., 2014, fig. 7.6	<i>Barskovisella renegata</i> sp. nov.
	CSGM 265/7		"	Mitta et al., 2014, fig. 7.7	"

\* Holotypes.

**Diagnosis.** Rostra small, less commonly medium-sized, conical to subconical in shape, very short to elongate. Cross section more or less laterally compressed with strongly flattened lateral sides anteriorly, becoming rounded posteriorly. In most species, except early ones, the ventral side is wider than or almost equal to dorsal at the anterior end. Posterior part often attenuated. Apical dorsolateral grooves characteristic of most Megateuthididae usually absent. Tip of alveolus central or ventrally displaced. Apical line straight or slightly curved, subcentral near posterior end, in large rostra becoming diffuse posteriorly, while apex becoming irregularly rounded. Rostrum shape not changing significantly during ontogeny. Epirostrum absent, but apex partly aragonitic and often showing distorted symmetry characteristic of epirostra.

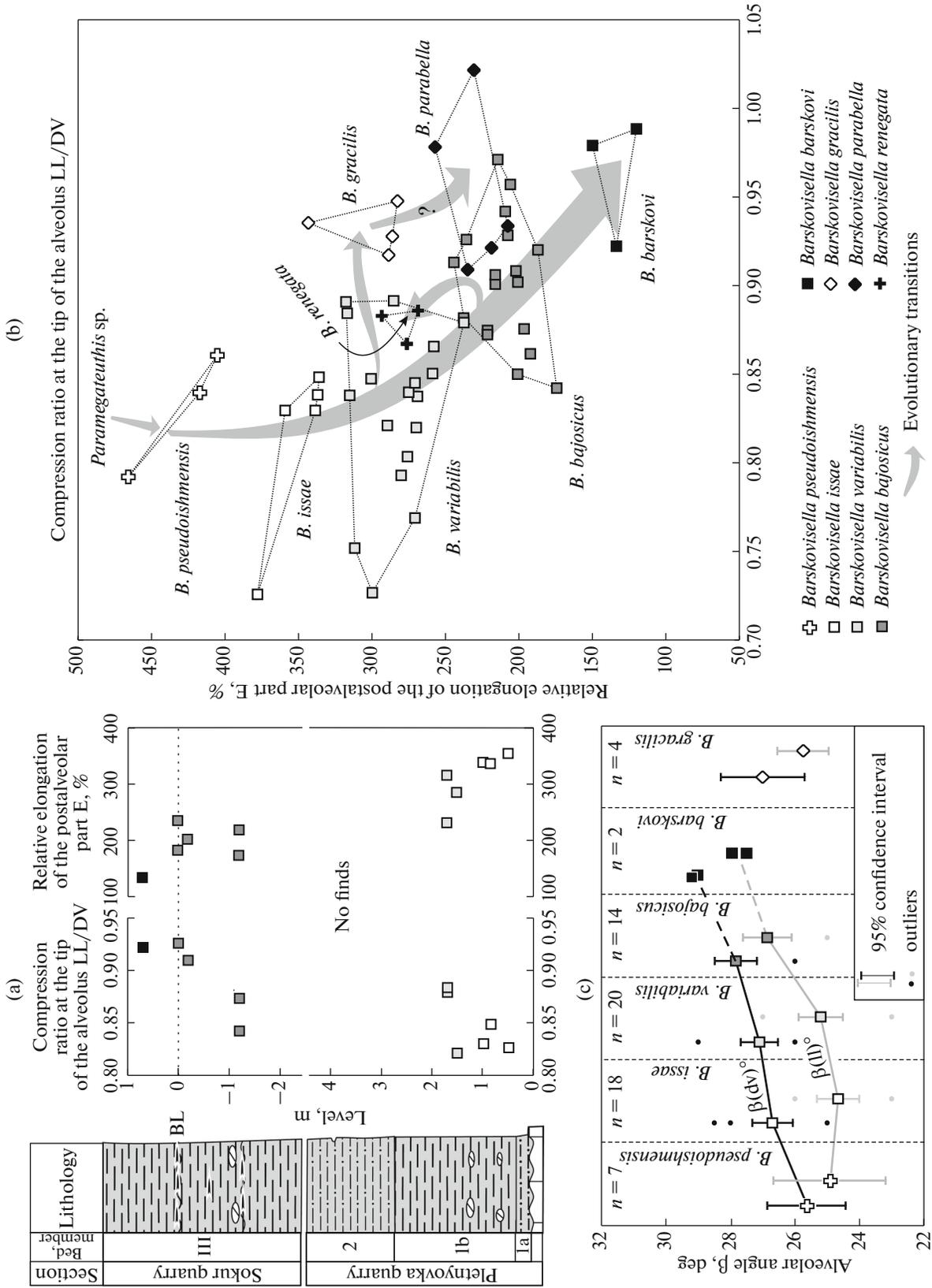
**Composition:** *Barskovisella pseudoishmensis* sp. nov.; *B. issae* sp. nov.; *B. variabilis* sp. nov.; *B. gracilis* sp. nov.; *B. bajosicus* (Ivanova, 1959) [= *B. bella* (Barskov in Mitta et al., 2004), subj. syn.]; *B. parabella* (Barskov in Mitta et al., 2004); *B. renegata* sp. nov.; *B. barskovi* sp. nov.

**Comparison.** This genus is distinguished from the most similar genus *Paramegateuthis* Gustomesov, 1960, as well as from the other small-sized Middle–Late Jurassic megateuthidids (undescribed genus from the Bathonian of India and *Chuvashiteuthis* Ippolitov et Berezin in Ippolitov et al., 2017), in the rounded posterior end of the rostrum lacking pronounced dorsolateral grooves. In addition, in most species of the genus *Barskovisella* gen. nov. at the anterior end, the ventral side is wider than the dorsal one, while in the genus *Paramegateuthis* their relation is opposite, allowing morphologically similar species to be readily distinguished (*B. renegata* sp. nov. and *P. timanensis* (Gustomesov, 1960)). There is a homeomorphic similarity with the Aalenian–early Bajocian *Homaloteuthis* Stolley, 1919; *Barskovisella* gen. nov. is distinguished from this genus by the smaller size, more strongly pronounced conical shape, and the presence of the lateral flattening in the anterior part of the rostrum. However, juvenile representatives of *Homaloteuthis* similar in size (Weis and Mariotti, 2008, pl. 5, fig. 3) are almost indistinguishable from adults of the early species *Barskovisella issae* sp. nov.

**Remarks.** The uniqueness of the megateuthidid rostra from the Bathonian of the Volga region has been noted by most authors and has been the subject of lively discussion in the literature in recent years. A find of a conical rostrum in the Bajocian–Bathonian beds of the Volga region was described for the first time by Ivanova (1959), who assigned it to the genus *Mesoteuthis* Lissajous, 1915, but noted significant differences from typical representatives of the genus. T.I. Nalnjaeva did not draw any firm conclusion on the generic assignment of this find, mentioning that the material was insufficient and assuming the possibility of assignment

to the genera *Paramegateuthis* or *Megateuthis* Bayle, 1878 (Nalnjaeva, 1974), and slightly later adding to this list genus *Nannobelus* Pavlow in Schwetsov, 1913 (Sachs and Nalnjaeva, 1975). Seltzer and Ivanov (1997) mentioned *Paramegateuthis* in the Bathonian of the Volga region, and in a later paper, Seltzer (see Mitta and Seltzer, 2002) listed “*Nannobelus* sp.” in the description of the Sokur quarry section; evidently, both of these identifications refer to the taxon under description. Somewhat later Barskov (Mitta et al., 2004) tentatively classified megateuthidids from Sokur quarry within *Nannobelus* on the basis of the absence of apical grooves, assuming the possibility of their assignment to a separate genus (see also Barskov in Mitta et al., 2011, p. 41). Nalnjaeva (in Meledina et al., 2009) suggested the possibility that the Sokur finds described by Barskov could be assigned either to *Mesoteuthis* Lissajous, 1915 or to *Brachybelus* Naef, 1922. O.S. Dzyuba first supported and substantiated the assignment of the Sokur specimens to the genus *Brevibelus* Doyle, 1992 (pro *Brachybelus* Naef, 1922) (Mitta et al., 2012, pp. 154–156), but later, on the basis of the study of the inner structure of the rostra, reclassified them within the genus *Paramegateuthis* Gustomesov, 1960, noting that they represent endemic species with aberrant morphology (Mitta et al., 2014, 2015). Noteworthy, she also included within the same species the finds from the Sokur quarry previously considered by all authors as belonging to another megateuthidid genus, *Paramegateuthis* Gustomesov, 1960 (Barskov in Mitta et al., 2004; Nalnjaeva in Meledina et al., 2009; Dzyuba in Mitta et al., 2012).

The discovery of slightly earlier but certainly closely related taxa in the lower Bathonian of Penza region described below as *B. pseudoishmensis* sp. nov., *B. issae* sp. nov., *B. variabilis* sp. nov., and *B. gracilis* sp. nov. allows re-evaluation of the systematic position of problematic Sokur taxa and leads to the following conclusions. Firstly, the morphology of the early species (from Pletnyovka quarry) possessing more laterally compressed and more elongated rostra compared with later species (from the Sokur quarry) conclusively refutes the idea that conical megateuthidids from the Bathonian of the Volga region can be placed within the genus *Brevibelus* Doyle, 1992, since the latter have considerably shorter rostra. Secondly, even before the main early Bathonian Boreal transgression followed by a wide immigration of cephalopods and bivalves from the Pechora Basin (Mitta et al., 2014), the territory of the Russian Plate was inhabited by an endemic megateuthidid lineage, which includes the problematic Sokur taxa. Thirdly, a comparative study of earlier members from the Pletnyovka quarry and later members from the Sokur quarry suggests the main evolutionary trends within this lineage. The species-level taxonomy presented below is based on analysis of these trends, the most important of which are gradual elongation of the rostrum combined with simultane-



**Fig. 3.** Evolution of main characters in *Barskovisella* gen. nov. (a) Trends in the main ratios (LL/DV and E) across the succession within the main lineage of *Barskovisella* (a compiled succession follows Gulyaev (in press) by aligning the top of Bed 2 in the Pleinyovka quarry with the base of Member III in the Sokur quarry). (b) Morphoadaptive fields, subdivision into species by the LL/DV and E ratios combined with the phylogeny scheme of *Barskovisella* gen. nov. Specimens with imprecise measurements and with  $D < 7.5$  mm are not shown. Unlike in Fig. 3a, specimens from the talus and figured specimens from Mitta et al. (2004, 2014) are also included. (c) Trends in phragmocone angles in the main lineage of *Barskovisella* and in *B. gracilis* sp. nov. For legend to the log, see Fig. 1.

ous decrease in lateral compression (Figs. 3a, 3b) and associated increase in the alveolar angle (Fig. 3c).

**Phylogeny.** The earliest *Barskovisella* gen. nov. originated from the Arcto-Boreal representatives of the genus *Paramegateuthis* Gustomesov, 1960, which immigrated to the Middle Russian Sea through the meridional strait from the north. This is supported by the following arguments.

Firstly, the tailings of the Pletnyovka quarry yielded elongated rostra with morphology transitional from *Paramegateuthis* to *Barskovisella* gen. nov.: some specimens described below as *B. pseudoishmensis* sp. nov., show indistinct dorsolateral grooves suggesting that these taxa apparently represent a link between the genera under consideration. Although their stratigraphic position in the section remains uncertain, they fit the major morphogenetic trends of *Barskovisella* gen. nov. as the initial member of a phylogenetic lineage.

Secondly, although species of the genus *Barskovisella* gen. nov. normally demonstrate ungrooved posterior end, some specimens may have three recapitulating apical grooves—paired dorsolateral and ventral one (Plate I, fig. 13), which is a feature of *Paramegateuthis*. In addition some specimens of *Barskovisella* spp. demonstrate a short apical dorsal groove (Plate I, figs. 4c, 9c), equivalent to that observable in the holotypes of *P. ishmensis* (Gustomesov, 1960) and *P. timanensis* (Gustomesov, 1960) (Ippolitov et al., 2017, figs. 5E1, 5F1), but not marked in other megateuthidid genera, and in some specimens, there is a short but well-developed ventral groove (Plate I, figs. 4a, 9a; Plate III, fig. 7a).

Thirdly, a slightly earlier late Bajocian belemnite assemblage in the Russian Plate (Pseudocosmoceras michalskii Zone) does not contain any belemnites with a conical rostrum clearly comparable with *Barskovisella* gen. nov. (Ippolitov, 2017). The records of such taxa in the late Bajocian of the Volga region should be considered either clearly erroneously dated (Ivanova, 1959; see below) or unconfirmed (Saltykov, 2008: “*Mesoteuthis* aff. *dorsetensis* Krim.” [sic!]). Therefore, the hypothesis of the *Barskovisella* deriva-

tion through the immigration of *Paramegateuthis* from the Arctic during an early opening episode of a through meridional strait from the Pechora Basin to the Russian Plate, preceding the main episode of wide immigration of *Pachyteuthis* and *Arcticoceras* (Mitta et al., 2004, 2014), seems better supported.

In conclusion, it should be noted that the consideration of the early Bathonian megateuthidids of the Russian Plate as a separate generic-rank taxon is based on the following arguments:

- They form a clear phylogenetic cluster composed of two parallel phylogenetic lineages developed on an isolated territory (occurrences of almost all species, except for the late *B. bajosicus* and *B. barskovi* sp. nov., are known only from the Volga region).
- Species composing this cluster possess at least one stable character distinguishing them among the synchronous megateuthidids: lateral flattenings disappear posteriorly, while the cross section near the apex becomes rounded and devoid of dorso-lateral apical grooves characteristic of most megateuthidids.
- The grooving pattern in belemnite classification is usually used as a stable character defining generic or higher rank; hence, neoendemic taxa described below should be treated as a separate genus.

**Occurrence.** Volga region (lower Bathonian, Oranicerias besnosovi Zone), Poland, Switzerland.

*Barskovisella pseudoishmensis* sp. nov.

Plate I, figs. 1, 2

**Etymology.** From the ancient Greek ψευδής (pseudo) and the specific name *ishmensis*.

**Holotype.** VSGM ISS/43, Penza region, Pletnyovka quarry, tailings; lower Bathonian, Oranicerias besnosovi Zone.

**Diagnosis.** *Barskovisella* with a laterally compressed rostrum in adult specimens LL/DV ≈ 0.76–0.86 and elongation E = 406–470%.

**Description.** The rostrum is elongated (E = 406–470%), subcylindrical in the alveolar region, becoming conical backwards: first in profile, and then

**Plate I.** Here and in Plates II and III, all figures except those specially marked are in natural size. The dot (•) marks the approximate position of the tip of the alveolus. In all cases, except where specially mentioned: (a) ventral view; (b) left-side view; (c) dorsal view; (d) right-side view; (e) alveolar view. (1, 2) *Barskovisella pseudoishmensis* sp. nov.: (1) holotype VSGM ISS/43; (2) specimen VSGM ISS/42, Pletnyovka quarry, from tailings; (3) *Barskovisella* cf. *pseudoishmensis* sp. nov., specimen VSGM ISS/6, rostrum of a young individual, Pletnyovka quarry, Bed 1, from talus; (4–8) *Barskovisella issae* sp. nov., Pletnyovka quarry: (4) holotype VSGM ISS/3, 100 cm above the base of Bed 1; (5) specimen VSGM ISS/20, Bed 1, from talus; (6) specimen VSGM ISS/21, 85 cm above the base of Bed 1 (6d—alveolar view); (7) specimen VSGM ISS/5, postalveolar part of a large rostrum, 50 cm above the base of Bed 1 ((7e) cross section on the anterior end; (7f) longitudinal section, polished); (8) *Barskovisella issae* sp. nov. or *B. variabilis* sp. nov., specimen VSGM ISS/7, juvenile rostrum, Pletnyovka quarry, Beds 1–2 (from talus); (9–14) *Barskovisella variabilis* sp. nov.: (9) holotype VSGM ISS/4, Pletnyovka quarry, 170 cm above the base of Bed 1; (10) specimen VSGM ISS/8, Pletnyovka quarry, 170 cm above the base of Bed 1 (10f—section at the posterior end); (11) specimen VSGM ISS/1, strongly compressed specimen of archaic appearance, Pletnyovka quarry, 150 cm above the base of Bed 1; (12) specimen VSGM BP-09664, Sokur quarry, ?from talus [unfigured specimen of *Paramegateuthis* cf. *manifesta* in Mitta et al., 2004, no CR-2805]; (13) specimen VSGM ISS/39, showing recapitulation of apical grooves (ventral and paired dorsolateral, among which the right dorsolateral is distinct, whereas the left dorsolateral is hardly visible), Pletnyovka quarry, from tailings; (14) specimen VSGM ISS/109, juvenile specimen with atypically strong lateral compression; Pletnyovka quarry, from tailings.



in outline. The apex is subcentral or slightly displaced dorsally. In the alveolar part of the rostrum, all margins are straight or weakly concave, and in the postalveolar part, the dorsal margin is almost straight, the ventral margin is noticeably convex, and the lateral sides are weakly concave. The cross section is oval, laterally compressed to a varying extent ( $LL/DV = 0.76-0.86$ ), near the apex becoming rounded or almost rounded. The upper half of lateral sides shows flattenings, extending across the full length of rostrum and tending to disappear near the apex. In the alveolar part of some specimens, they extend to the entire width of the lateral sides. The apical part is not completely preserved in available specimens; however, weak striation is observed in this area, indicating the striated character of the apex.

The alveolus occupies approximately  $1/4-1/3$  of the rostrum length, noticeably laterally compressed; its angles are  $\beta (dv) = 24^\circ-27.5^\circ$  and  $\beta (ll) = 23^\circ-27^\circ$ ; the tip is subcentral.

**Dimensions and ratios.** See Table 2.

**Variability.** The rostra in the collection vary in the expression of lateral flattenings and their length, compression rate, and less so in the elongation.

**Comparison.** This species is distinguished from all known species of the genus *Barskovisella* gen. nov. by the stronger elongation of the rostrum ( $E > 400\%$ ) and from representatives of the genus *Paramegateuthis* with similar rostrum morphology (in particular, *P. ishmen-sis* (Gustomesov, 1960)) by the absence of apical dorsolateral grooves.

**Occurrence.** Only the type locality.

**Remarks.** The lateral flattenings in the anterior part of the rostra result from the flattening and subsequent fusing of a pair of lateral lines running from the anterior end: narrower lower lateral and wider upper lateral. These lateral lines are sometimes clearly separated by an angular shoulder, occurring slightly below the middle of the lateral sides of the rostrum. In some cases, the lower lateral lines have an appearance of “doppellinien” (Plate III, fig. 8e).

Precise positions of the *B. pseudoishmensis* sp. nov. finds in the studied succession remain unclear, but this species is apparently ancestral to all other species of *Barskovisella* gen. nov. Its lateral flattenings extending sometimes to the apex should be considered as relicts of dorsolateral grooves characteristic of megateuthids. In addition, a short dorsolateral groove is observed near the broken posterior end of the holotype (Plate I, fig. 1d). These characters of the described species are similar to those in representatives of the genus *Paramegateuthis*; thus, its placement in *Barskovisella* is to some extent provisional: in fact, the type series contains specimens well corresponding to the diagnosis of the genus *Barskovisella* gen. nov. (paratype VSGM ISS/42), as well as specimens with characters transitional from *Paramegateuthis* (holotype).

In the rounded cross section of the apical part, available rostra of *B. pseudoishmensis* sp. nov. are very similar to some rostra described as *Paramegateuthis subishmensis* Stoyanova-Vergilova, 1983 from the lower Bajocian and lower/upper Bajocian boundary beds of the Yuryung-Tumus Peninsula in northern Siberia (de Lagausie and Dzyuba, 2017, pl. 1, figs. 15–17; Dzyuba and de Lagausie, 2017, fig. 5e). Among the known species of the genus *Paramegateuthis*, these forms are most similar to the early members of *Barskovisella* gen. nov. and can be considered as a hypothetical ancestor of *B. pseudoishmensis* sp. nov. Although *P. subishmensis* was originally described from the upper part of the lower Bajocian of Bulgaria (Stoyanova-Vergilova, 1983), the absence of similar forms both in the upper Bajocian Michalskii Zone of the Volga region (Ippolitov, 2017) and in the well-studied assemblage of the upper Bajocian Garantiana Zone of the Donets Basin (Borissjak, 1908; Nikitin, 1981) allows the hypothesis linking *B. pseudoishmensis* sp. nov. to Tethyan specimens of *P. subishmensis* to be rejected.

**Material.** 7 rostra (3 relatively complete, the rest are fragments) from the tailings of the Pletnyovka quarry.

*Barskovisella issae* sp. nov.

Plate I, figs. 4–8; pl. III, figs. 8b, 8c

**Etymology.** After the Issa River, as the type locality is in the valley of this river.

**Holotype.** VSGM ISS/3, Penza region, Pletnyovka quarry, Bed 1, 100 cm above the base; lower Bathonian, Oraniceras besnosovi Zone, O. sp. nov. A Biohorizon (lower part) (Gulyaev and Ippolitov, 2017).

**Diagnosis.** *Barskovisella* with rostrum compression in adult specimens  $LL/DV = 0.73-0.86$  and elongation  $E = 336-360\%$ .

**Description.** The rostrum is moderately elongated ( $E = 336-360\%$ ), conical in profile and subconical in outline. The apex is slightly displaced dorsally. The dorsal margin is weakly convex in the alveolar region, concave in the postalveolar part, and almost straight near the apex. The lateral and ventral margins are almost straight or weakly convex along the entire length, gradually becoming convex near the apex. The cross section is oval to rounded-subtrapezoid, strongly laterally compressed ( $LL/DV = 0.73-0.86$ ), in the alveolar part with flattened lateral sides, parallel or slightly inclined dorsally; toward the posterior end, the cross section first becomes oval and then rounded. Apex is striated.

The alveolus occupies approximately  $1/3-2/5$  of the rostrum length, distinctly compressed laterally; its angles are  $\beta (dv) = 24^\circ-29^\circ$  and  $\beta (ll) = 23^\circ-27^\circ$ ; the alveolar tip is slightly displaced ventrally ( $R_v/DV' = 0.46$  in specimen VSGM ISS/05).

**Table 2.** Measurements and ratios in the rostra of *Barskovisella* spp.

No.	Mm	Section	Bed, level	R, mm	PA, mm	DV, mm	LL, mm	LL/DV	D, mm	E, %	$\beta$ (dv), °	$\beta$ (ll), °	R <sub>v</sub> /DV'	Notes/source
<i>Barskovisella pseudoishmensis</i> sp. nov.														
VSGM ISS/43	A	P	Talus	59.0	50.7	12.2	9.7	0.79	10.9	466	24	23		Plate I, fig. 1
VSGM ISS/42	A	P	Talus	53.6	40.0	10.6	9.2	0.86	9.9	406	26	26		Plate I, fig. 2
VSGM ISS/94	A	P	Talus	50.2	46.8	10.4	9.6		10.0	470	26.5	26		
VSGM ISS/73	A	P	Talus	39.8	33.7	8.8	7.4	0.84	8.1	418	27	27.5		
<i>Barskovisella issae</i> sp. nov.														
VSGM ISS/03	A	P	1↑100	58.7	35.2	11.4	9.5	0.83	10.4	339	26	24	0.46	Plate I, fig. 4
VSGM ISS/05	A	P	1↑50	47.7	47.7	14.8	12.2	0.83	13.5					Plate I, fig. 7; Plate III, figs. 8b, 8c
VSGM ISS/21	A	P	1↑85	47.2	32.0	10.4	8.8	0.85	9.5	336	26	24		Plate I, fig. 6
VSGM ISS/20	A	P	Talus	51.1	33.3	10.8	9.0	0.84	9.9	337	26.5	24		Plate I, fig. 5
VSGM ISS/88	A	P	Talus	50.3	41.0	12.7	9.2	0.73	10.8	378	28	22		
VSGM ISS/93	A	P	Talus	48.8	49.2	15.0	12.5	0.83	13.7	359				
VSGM ISS/91	A	P	Talus	46.6	37.2	11.9	9.3	0.78	10.5	353	27	25		
<i>Barskovisella variabilis</i> sp. nov.														
VSGM ISS/04	A	P	1↑170	50.0	27.2	12.3	10.8	0.88	11.5	237	26	25.5		Plate I, fig. 9; Plate III, fig. 8d
VSGM ISS/01	A	P	1↑150	37.8	29.0	11.1	9.1	0.82	10.0	289	26	23		Plate I, fig. 11
VSGM ISS/02	A	P	1↑150	>58.5										
VSGM ISS/08	A	P	1↑170	42.1	33.3	11.2	9.9	0.88	10.5	316	26	24		Plate I, fig. 10
VSGM ISS/10	A	P	Talus	37.1	30.3	9.6	8.4	0.88	9.0	337	26	25		
VSGM ISS/39	A	P	Talus	24.2	24.1	9.0	8.0	0.89	8.5	285				Plate I, fig. 13
VSGM ISS/109	A	P	Talus	16.8	9.0	4.9	2.6	0.53	3.6	253	29	25		Plate I, fig. 14
VSGM ISS/63	A	P	Talus	30.6	22.1	9.0	7.0	0.78	7.9	280	27	25.5		
VSGM ISS/70	A	P	Talus	37.2	26.4	9.8	7.4	0.75	8.5	311	28	26		
VSGM ISS/89	A	P	Talus	49.1	32.5	10.8	9.7	0.89	10.2	318	27	26.5		
VSGM ISS/100	A	P	Talus	57.2	31.4	10.9	9.1	0.84	10.0	314	29	25.5		
VSGM ISS/62	A	P	Talus	33.1	24.7	8.9	7.6	0.85	8.2	300	28	27		
VSGM ISS/80	A	P	Talus	36.6	25.6	10.0	7.3	0.73	8.6	299	25	22		
VSGM ISS/53	A	P	Talus	37.8	24.0	9.6	7.6	0.79	8.6	280	26	23		
VSGM ISS/61	A	P	Talus	31.4	25.8	10.4	8.4	0.80	9.3	276				

Table 2. (Contd.)

No.	Mm	Section	Bed, level	R, mm	PA, mm	DV, mm	LL, mm	LL/DV	D, mm	E, %	$\beta$ (dv), °	$\beta$ (ll), °	R <sub>v</sub> /DV'	Notes/source
VSGM ISS/64	A	P	Talus	36.5	26.9	10.7	9.0	0.84	9.8	274	28	26		
VSGM ISS/71	A	P	Talus	24.2	20.7	8.7	6.7	0.77	7.7	270				
VSGM ISS/104	A	P	Talus	37.7	26.2	10.7	8.8	0.82	9.7	269	27	26.5		
VSGM ISS/57	A	P	Talus	35.1	22.0	8.9	7.5	0.84	8.2	269	25	23		
VSGM ISS/79	A	P	Talus	33.7	26.7	11.2	9.5	0.85	10.3	259	28	26		
VSGM ISS/56	A	P	Talus	31.7	25.0	10.4	9.0	0.87	9.7	258				
VSGM BP-09664	A	S	?	33.4	30.3	12.2	10.3	0.85	11.2	271				Mitta et al., 2004 (not figured); Plate I, fig. 12
<i>Barskovisella gracilis</i> sp. nov.														
VSGM ISS/11	A	P	Talus	49.4	29.1	10.6	9.7	0.92	10.1	288	27	26		Plate II, fig. 9; Plate III, fig. 8a
VSGM ISS/45	A	P	Talus	57.4	38.6	14.1	13.3	0.95	13.7	282	28	26		Plate II, fig. 8
VSGM ISS/44	A	P	Talus	73.2	52.0	15.7	14.7	0.94	15.2	343	27	26		Plate II, fig. 11
VSGM SOK/117	A	S	Talus	60.9	41.8	15.2	14.1	0.93	14.6	286	26	25		Plate II, fig. 10
<i>Barskovisella bajosticus</i> (Ivanova, 1959)														
<b>Holotype</b>	<b>B</b>			<b>38.0</b>	<b>17.2</b>	<b>8.2</b>	<b>8.5</b>	<b>0.96</b>	<b>8.4</b>	<b>206</b>				Ivanova, 1959, pl. 16, fig. 1
VSGM ISS/41	A	P	Talus [Bed2b?]	27.5	16.9	8.2	7.2	0.88	7.7	221				
VSGM ISS/40	A	P	Talus [Bed3-4]	38.6	23.2	11.3	10.2	0.91	10.8	216	28			Plate II, fig. 1
VSGM ISS/48	A	P	Talus	21.9	20.7	9.2	8.2	0.88	8.7	238				
VSGM ISS/92	A	P	Talus	44.3	24.3	11.9	10.7	0.90	11.3	216	26	25		Plate II, fig. 2
VSGM SOK/24	A	S	BL↓120	35.7	13.6	8.5	7.2	0.84	7.8	174	28	27		Plate II, fig. 5
VSGM SOK/43	A	S	BL↓120	40.4	21.0	10.2	8.9	0.87	9.5	221	29	27		Mitta et al., 2014, fig. 7.8
VSGM SOK/45	A	S	BL↓120	11.7	7.7	4.3								Plate II, fig. 4
CSGM 256/8	B	S	BL↓20		19.5	9.2	10.1	0.91	9.6	202				Mitta et al., 2014, fig. 7.4
VSGM SOK/61	A	S	BL	60.5	37.0	16.4	15.1	0.93	15.7	235	28	27	0.45	Mitta et al., 2004 (not figured)
CSGM 256/4	B	S	BL		31.0		17.0			182	27			Mitta et al., 2004 (not figured)
VSGM BP-09668	A	S	BL	59.1	30.3	15.2	14.1	0.93	14.6	207	29	27.5		Mitta et al., 2004 (not figured)
VSGM BP-09669	A	S	BL	31.7	15.7	8.8	8.1	0.92	8.4	186	28	26.5		Mitta et al., 2004 (not figured)
VSGM BP-09737	A	S	BL	26.4	14.9	7.1	6.9	0.97	6.9	214	26	26		Mitta et al., 2004 (not figured)
VSGM BP-09663	A	S	BL	29.7	17.8	9.6	8.2	0.85	8.8	201	28	26		Mitta et al., 2004 (not figured)

Table 2. (Contd.)

No.	Mm	Section	Bed, level	R, mm	PA, mm	DV, mm	LL, mm	LL/DV	D, mm	E, %	$\beta$ (dv), °	$\beta$ (II), °	R <sub>v</sub> /DV <sup>r</sup>	Notes/source
VSGM BP-09666	A	S	Talus	65.5	40.3	17.3	15.8	0.91	16.5	244	29	28		Mitta et al., 2004, pl. 3, fig. 6; <b>holotype of <i>Nannobelus bellus</i></b> <b>Barskov in Mitta et al., 2004</b>
VSGM BP-09667	A	S	Talus	45.6	26.6	14.5	12.7	0.88	13.6	196	28	26		Mitta et al., 2004, pl. 3, fig. 5
VSGM SOK/18	A	S	Talus	44.8	26.9	14.1	12.8	0.90	13.4	200	27	25		Plate II, fig. 3
VSGM SOK/116	A	S	Talus	32.9	20.0	9.9	9.3	0.94	9.6	209	30	30		Gilliéron, 1873, pl. 8, fig. 2
—	C			16.9	10.5	5.3	4.9	0.92	5.1	204				
<i>Barskovisella parabell</i> (Barskov in Mitta et al., 2004)														
VSGM BP-09670	A	S	?	55.4	28.4	12.2	12.5	1.02	12.3	230				Mitta et al., 2004, pl. 3, fig. 7; <b>Plate III, fig. 1</b>
VSGM SOK/118	A	S	~BL	58.9	36.6	14.4	14.1	0.98	14.2	257	27	27	0.37	Plate III, fig. 3
VSGM BP-09672	A	S	~BL	38.2	18.2	9.1	8.5	0.93	8.8	207	28	27		Mitta et al., 2004 (not figured)
VSGM BP-09720	A	S	~BL	34.1	16.8	8.0	7.4	0.92	7.7	218				Mitta et al., 2004, pl. 3, fig. 3; Plate III, fig. 4
VSGM SOK/104	A	S	talus	30.3	22.0	9.8	9.0	0.91	9.4	234	27	26		Plate III, fig. 2
<i>Barskovisella barskovi</i> sp. nov.														
VSGM SOK/101	A	S	BL↑40	24.3	10.4	8.1	7.5	0.92	7.8	134	29	28		<b>Plate II, fig. 6</b>
VSGM BP-09671	A	S	~BL	34.7	14.1	9.5	9.3	0.98	9.4	150	29	27.5		Mitta et al., 2004, pl. 3, fig. 8
VSGM BP-09682	A	S	~BL	21.4	9.1	7.6	7.6	0.99	7.6	120				Mitta et al., 2004 (not figured); Plate II, fig. 7
<i>Barskovisella renegata</i> sp. nov.														
VSGM SOK/50	A	S	BL↓100	47.8	35.0	13.8	12.3	0.89	13.0	269				Plate III, fig. 5
VSGM SOK/63	A	S	BL	44.4	28.0	10.9	9.4	0.87	10.1	276				
VSGM SOK/100	A	S	BL	26.0	16.7	8.8					27	0.40		Plate III, fig. 6
VSGM SOK/85	A	S	?BL	48.6	40.0	14.5	12.8	0.88	13.6	293	27	25.5		<b>Plate III, fig. 7</b>
CSGM 256/7	B	S	BL↑150	31.5	31.5	10.7	13.2	0.81	11.8	266				Mitta et al., 2014, fig. 7.7

Low precision measurements are indicated in italics. Holotype measurements are in bold. Abbreviations: Mm—measurement method (A—from the specimens; B—from published photographs; C—from published drawings); P—Pletnyovka quarry, S—Sokur quarry; BL—belemnite level. The indications like “↑50” mean “50 cm above the base of Bed 1”; “BL↓ (↑)100” means “100 cm below (above) the belemnite level.”

**Dimensions and ratios.** See Table 2.

**Variability.** In specimens collected in situ, insignificant: it is reflected only in somewhat different morphology of lateral flattenings and the possibility of distinction of certain lateral lines constituting them.

**Comparison.** The combination of two characters—strong lateral compression ( $LL/DV \leq 0.86$ ) at the anterior end and significant elongation of the post-alveolar region ( $320 < E < 400\%$ )—allows this species to be confidently recognized among all known species of *Barskovisella* gen. nov. This species is distinguished from *B. pseudoishmensis* sp. nov. by the shorter rostrum and the noticeably conical shape.

**Occurrence.** Only the type locality, interval 50–100 cm above the base of Bed 1.

**Remarks.** Young rostra early acquire proportions characteristic of adult specimens, but at the earliest stages, they are still short-conical in shape (Plate I, fig. 8), as characteristic of most members of the family Megateuthidae.

In the holotype, the posterior end shows indistinct apical striae, among which four are most incised: dorsal, paired dorsolateral ones (Plate I, fig. 4c), and also a wide, shallow ventral one (Plate I, fig. 4a). All these represent relicts of grooves characteristic of *Paramegateuthis*.

Small inflations are often observed on the rostrum surface immediately near the apex (Plate I, figs. 7b, 7d; Plate III, fig. 8b), and the posterior end may be slightly asymmetrical. The longitudinal section of the specimen VSGM ISS/05 shows that, near the apical line and especially near the apex, the rostrum is composed of whitish carbonate matter different from the main part of the rostrum. It also forms tiny lenses within the layered structure of the rostrum, above which the inflations are observed (Plate III, fig. 8c). Such whitish calcite, judging from the figures available from the literature, is common in late Megateuthidae (Pugaczewska, 1961, pl. 7, figs. 1, 7; Schlegelmilch, 1998, pl. 11, figs. 2, 8; pl. 13, fig. 2), for which a “diffuse” apical line tending to form an epirostrum was repeatedly recorded (Weis and Mariotti, 2008). The curved apical part of *B. issae* sp. nov., slightly resembling an epirostrum, cannot be considered as such because the rostrum outline and profile are stable in ontogeny and no drastic change of shape similar to those shown in the literature (Schlegelmilch, 1998, pl. 9, fig. 9; pl. 10, figs. 5, 7; Weis and Mariotti, 2008, pl. 6, fig. 1; Arkhipkin et al., 2015, figs. 4, 5) or axial structureless deposits (Arkhipkin et al., 2015, fig. 6) have been recorded in any *Barskovisella* species. Nevertheless, the homology of the epirostrum with its characteristic distortions of symmetry and structureless central part to the posterior end of the *Barskovisella* rostra and their diffuse apical line looks evident.

In addition, the X-ray diffraction analysis of the mineral composition of the matter in the whitish axial part of the rostrum VSGM ISS/05 identified the pres-

ence of an aragonite component (up to 30%), while two other samples collected from the central and peripheral zones on the anterior end of the same polished specimen were established as being of 100% calcitic composition. There is an opinion that the rostra originally were calcitic, while the epirostra were aragonitic (Bandel and Spaeth, 1988); and this is taken into account by many modern authors (cf. Arkhipkin et al., 2015). However, these assumptions were not supported by any solid evidence, and as a result, currently there is no accepted view on the primary mineralogical composition of either rostra or epirostra. Some authors (Dauphin et al., 2007) consider that rostra were originally aragonitic and later were partly or completely recrystallized into calcite, whereas others (Stevens et al., 2017) indicate that both rostra and epirostra were originally calcitic. Considering that the clayish deposits of the Pletnyovka quarry contain both well-preserved calcitic fossils (belemnite rostra, bivalvan shells) and aragonitic ones (nacre of the ammonite shells and phragmocones of belemnites), the established mixed composition of the axial part of the rostrum of *B. issae* gen. et sp. nov. is likely to be a primary characteristic of rostra not only of the species under consideration but also of other megateuthids with a “diffuse” axial line.

**Material.** 21 rostra and identifiable fragments from the Pletnyovka quarry: 3 from the lower part of the section (interval 50–100 cm above the base of Bed 1), while the other specimens were found in the tailings.

*Barskovisella variabilis* sp. nov.

Plate I, figs. 9–14; Plate III, fig. 8d

*Paramegateuthis* cf. *pressa*: (pars) Barskov in Mitta et al., 2004, p. 22 [only unfigured specimen CR-2805].

**Etymology.** From the Latin *variabilis* (variable).

**Holotype.** VSGM ISS/4, Penza region, Pletnyovka quarry, 170 cm above the base of Bed 1; lower Bathonian, Oraniceras besnosovi ammonite Zone, Oraniceras sp. nov. A Biohorizon (upper part) (after Gulyaev and Ippolitov, 2017).

**Diagnosis.** *Barskovisella* with elongation  $E = 237–318\%$ , with compression  $LL/DV = 0.73–0.89$ ; significant compression ( $<0.85$ ) never associated with significant elongation ( $>300\%$ ). In outline, shape of alveolar region always subcylindrical, with subparallel lateral margins.

**Description.** The rostrum is short to moderately elongated ( $E = 237–318\%$ ), from conical to subconical in profile, varying in outline (usually subconical to subcylindrical). The apex of the rostrum is slightly displaced dorsally, and the degree of tapering of the apical part varies. The dorsal and ventral margins are most commonly weakly convex, less commonly straight; the lateral ones are straight, but in some specimens each of them can be weakly concave. The cross section is oval, laterally compressed

(LL/DV = 0.73–0.89), in the alveolar region always with flattened lateral sides, subparallel to each other. The cross section in the apical part is rounded. Sometimes the lateral flattenings show a weak shoulder separating them into a narrower lower and a wider upper zone. Sometimes apical striae are visible, with the ventral striation being most prominent (Plate I, fig. 9a). The holotype of *B. variabilis* sp. nov., which has an exceptionally well-preserved surface, shows rostrum microsculpture, represented in the alveolar region by microgranulation and in the postalveolar region by tiny irregular carinae. The transition between these zones is sharp (Plate I, figs. 9a–9d; Plate III, fig. 8d). The microornamentation is the strongest on the dorsal and ventral sides, whereas the lateral sides demonstrate granulation only in the anterior half of the alveolar part.

The alveolus occupies approximately 1/2 of the rostrum length, distinctly laterally compressed. Its angles are  $\beta$  (dv) = 26°–29° and  $\beta$  (ll) = 22°–27°. The alveolar tip is slightly displaced ventrally.

**Dimensions and ratios.** See Table 2.

**Variability.** *B. variabilis* sp. nov. specimens vary considerably in the degree of tapering and the general shape of the apical part, as well as in the degree of lateral compression; such variability is reflected in the name of the species. The morphology of the alveolar part of the rostrum is stable.

**Comparison.** *B. variabilis* sp. nov. is distinguished from the ancestral species *B. issae* sp. nov. by a generally slightly less compressed rostrum (LL/DV normally 0.82–0.88 instead of normally 0.77–0.84 in *B. issae* sp. nov.) and less elongated rostrum (usually  $E < 300\%$ ). The descendant species *B. bajosicus* is slightly less compressed (DV/LL = 0.84–0.96) and noticeably less elongated (usually  $E = 195$ –220%). It also generally has a more conical shape, which is particularly noticeable in outline. The co-occurring (?) species *B. gracilis* sp. nov. has a distinctly conical shape and is less compressed (LL/DV  $\geq 0.92$ ); it also does not have pronounced lateral flattenings. These characters also distinguish the described species from *B. parabella* (Barskov). A lattermost *Barskovisella* species, *B. barskovi* sp. nov., is characterized by less pronounced lateral compression (LL/DV  $\geq 0.90$ ) and a very short rostrum ( $E < 150\%$ ).

**Occurrence.** Lower Bathonian of the Volga region (Pletnyovka and Sokur quarries); Oraniceras besnosovi Zone, O. sp. nov. A Biohorizon (upper part) (after Gulyaev and Ippolitov, 2017).

**Remarks.** The lowermost find of *B. variabilis* sp. nov. (specimen VSGM ISS/1 collected at 150 cm above the base of Bed 1 in the Pletnyovka quarry; Plate I, fig. 11) has an archaic appearance, being similar to the ancestral species *B. issae* sp. nov. by the strong compression (LL/DV = 0.82) of the proportionally shorter rostrum than in *B. issae* sp. nov. ( $E = 289\%$ ), whereas one of the rostra found in the talus (specimen VSGM

ISS/10) is comparable with *B. issae* sp. nov. in its elongation, but is less compressed (LL/DV = 0.88,  $E = 337\%$ ). On the other hand, the variability range in the described species overlaps that of the descendant species *B. bajosicus* (Fig. 3b), and potentially this may somewhat complicate the identification of isolated specimens.

The only known find of *B. variabilis* sp. nov. from the Sokur quarry was previously identified by I.S. Barskov as *Paramegateuthis* cf. *pressa* (specimen VSGM BP-09664; Plate I, fig. 12). Its anterior end has an old broken, dirty surface, which indicates that the specimen comes from the talus; hence, it did not necessarily originate from the “belemnite level” as was originally indicated. It is likely that this specimen comes from a lowermost part of the clay pit, which was completely excavated and inaccessible for study in the 2000s, as was mentioned for some ammonite finds (Mitta and Seltzer, 2002; Mitta et al., 2004).

**Material.** 34 rostra and identifiable fragments from the Pletnyovka quarry: 4 from the interval 150–170 cm above the base of Bed 1, the others from the tailings.

#### *Barskovisella bajosicus* (Ivanova, 1959)

Plate II, figs. 1–5

*Belemnites Escheri*: Gilliéron, 1873, p. 197, pl. 8, fig. 2.

*Mesoteuthis bajosicus*: Ivanova and Khabarova, 1956, p. 103 [nomen nudum]; Ivanova, 1959, pp. 365–366, pl. 26, figs. 1a–1g.

*Mesoteuthis* sp. n. inden.: Kamysheva-Elpatievskaya, 1956, p. 144.

*Nannobellus bellus*: Barskov in Mitta et al., 2004, p. 19, pl. 3, figs. 5, 6.

*Paramegateuthis* cf. *pressa*: (pars) Barskov in Mitta et al., 2004, p. 22 [only unfigured specimen CR-2804].

*Paramegateuthis* cf. *manifesta*: (pars) Barskov in Mitta et al., 2004, pp. 22–23 [only unfigured specimen CR-2802].

*Paramegateuthis parabella*: (pars) Dzyuba in Mitta et al., 2014, figs. 7.4, 7.8 [non fig. 7.5 = *B. barskovi* sp. nov.].

*Paramegateuthis bella*: (non) Dzyuba in Mitta et al., figs. 7.6, 7.7 [= *B. renegata* sp. nov.].

**Holotype by monotypy.** Specimen figured by Ivanova (1959, pl. 26, figs. 1a–1g), Saratov region, basin of the Kurdyum River, Borehole 4k; lower Bathonian [in the original publication, the age is indicated as “Bajocian”], O. besnosovi Zone and ?Biohorizon; lost.

**Diagnosis.** *Barskovisella* with an elongation  $E = 174$ –244% in adults (usually 195–220%) and with a compression ratio LL/DV  $\geq 0.84$ –0.96 (usually  $> 0.87$ ).

**Description** (see also Mitta et al., 2004, p. 19). The rostrum is short ( $E = 174$ –244%, usually  $< 220\%$ ), with a conical profile, subcylindrical to subconical, rarely conical in outline. The rostrum apex is slightly displaced dorsally. The ventral margin is straight or convex, the lateral margins are usually straight or weakly convex, but in the apical region they all become convex. The dorsal margin is convex, less

commonly straight, in the apical region slightly concave, but occasionally can be convex. The cross section is oval, laterally compressed ( $LL/DV = 0.84\text{--}0.96$ ), in the alveolar part always with flattened subparallel lateral sides. Near the apex, the cross section is rounded. Apical striation is present, and on the dorsal side, fine hatchings extend along the entire length of the postalveolar region. In the specimen VSGM SOK/116 (Plate II, fig. 3b), the apical region shows shallow and hardly noticeable short dorsoventral grooves not exceeding 2 mm in length.

The alveolus occupies about 1/2 of the rostrum length, is slightly laterally compressed; its angles are  $\beta (dv) = 26^\circ\text{--}29^\circ$  and  $\beta (ll) = 25^\circ\text{--}28^\circ$ ; the alveolar tip is shifted ventrally ( $R_v/DV' = 0.41$  in specimen VSGM SOK/116).

**Dimensions and ratios.** See Table 2.

**Variability.** Variations of the lateral compression rate  $LL/DV$  are very considerable. It is possible that specimens assigned herein to *B. bajosicus* originate from somewhat different intervals of the section and can be subdivided as chronospecies/chronosubspecies (see below). The shape of the cross section is also variable, from rounded-squared to trapezoid, and the associated appearance of the lateral flattenings also varies.

**Comparison.** From the ancestral species *B. variabilis* sp. nov. is distinguished by the less elongated rostrum ( $E = 174\text{--}244\%$  in *B. bajosicus* against  $237\text{--}318\%$  in *B. variabilis* sp. nov.). Although the ranges of variability of this character somewhat overlap, *B. bajosicus* is readily recognized by its pronounced subconical shape in outline. Juvenile specimens of *B. bajosicus* (Plate II, fig. 5) are relatively easily distinguished from those in the ancestral taxa *B. issae/variabilis* spp. nov. (Plate I, fig. 8) by the less elongated rostra, which allows them to be distinguished even by juvenile rostra. The co-occurring species *B. parabella* differs in the complete shift of the apex to the dorsal side and generally in stronger elongation ( $E = 207\text{--}257\%$ ), although young specimens of both species are not clearly distinguishable. The descendant species *B. barskovi* sp. nov. has a very short postalveolar region ( $E \leq 150\%$ ).

**Occurrence and age.** Sokur quarry; interval 0–120 cm below the “belemnite level” (possibly also occurs below that); lower Bathonian, O. besnosovi/A. excentricum Zone and Biohorizon; (?)

Pletnyovka quarry; lower Bathonian, O. besnosovi Zone, O. sp. nov. B (?) Biohorizon (after Gulyaev and Ippolitov, 2017); Switzerland.

**Remarks.** *B. bajosicus* was originally described from a single young rostrum (Ivanova, 1959), and in most subsequent papers with descriptions and identifications of the Bajocian—early Bathonian belemnites of the Volga Region (Mitta and Seltzer, 2002; Mitta et al., 2004, 2011; Saltykov, 2008), this species was not considered even in comparisons. Only Dzyuba (in Mitta et al., 2014) mentioned it as an apparent relative of the Sokur specimens of “*Paramegateuthis*.”

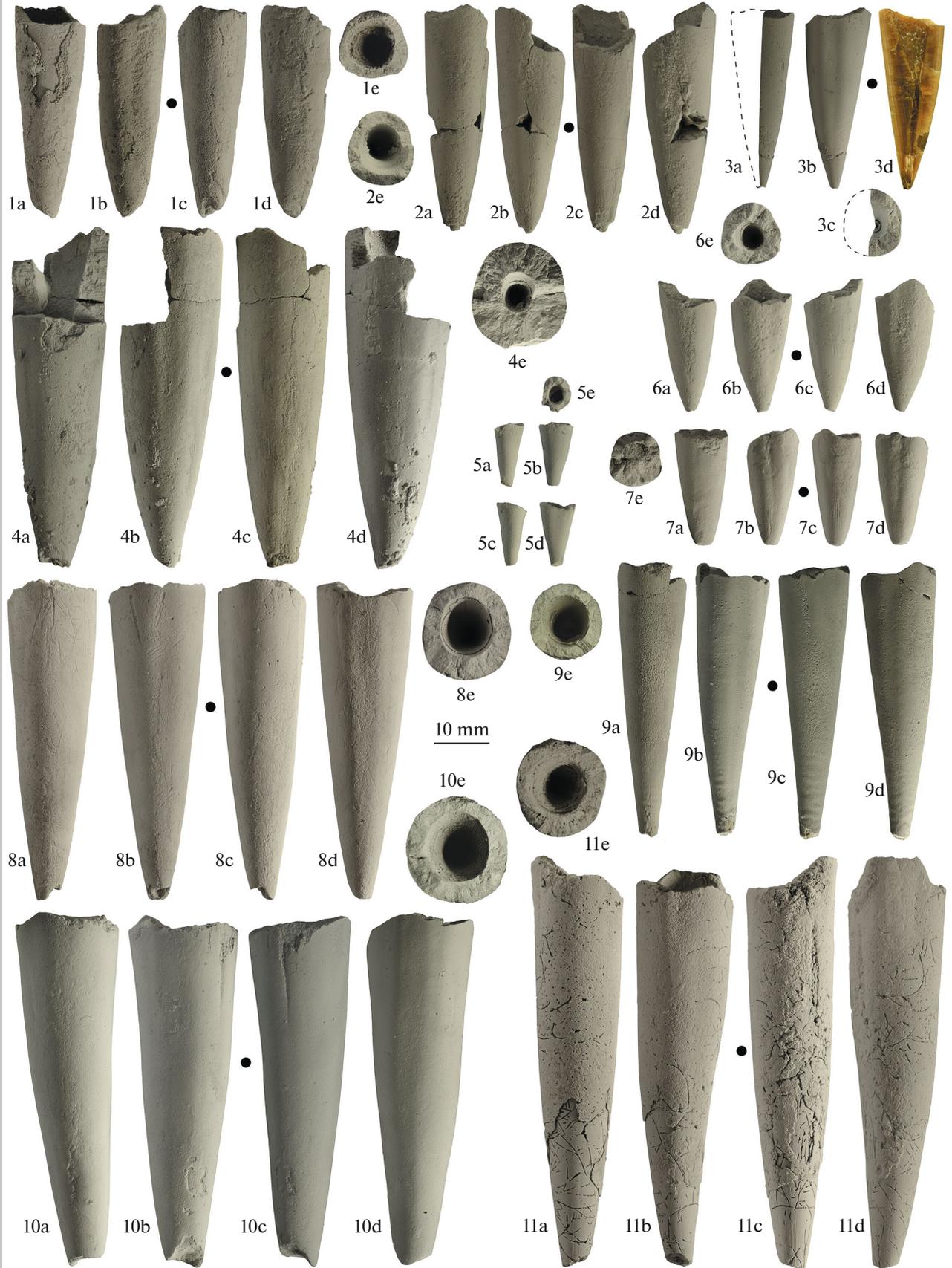
However, of the entire spectrum of known species of *Barskovisella*, the holotype of *B. bajosicus* is similar to specimens described by Barskov from the “belemnite horizon” in the Sokur quarry as *Nannobelus bellus* ( $LL/DV = 0.91\text{--}0.97$ ,  $E = 186\text{--}244\%$ ) in both principal ratios ( $LL/DV = 0.96$ ,  $E = 206\%$ ). Measurements in the original descriptions of *B. bajosicus* were performed accurate to 0.5 mm; therefore, the cited ratios have poor accuracy too. In addition, the figured rostrum gives the false impression of being strongly elongated and comparable by this to *B. variabilis* sp. nov. That is because the cross section figured by Ivanova (1959, pl. 16, fig. 1g) apparently corresponds not to a preserved rostrum anterior edge (in that case a missing part of the rostrum would have been somehow recognizable on the dorsal side on the photo of the cross section), but to the cross section located slightly posteriorly and identifiable by the breakage line present. The remeasurements of the holotype obtained from photographs of both the left and right sides, together with the original illustration of the cross section and elongation indicated by Ivanova, show that *Nannobelus bellus* Barskov and *Mesoteuthis bajosicus* Ivanova are identical.

Mentions of “*Mesoteuthis bajosicus* Ivanova” from Siberia in the literature (Zakharov and Shurygin, 1978, pp. 17, 27, 28) are related to species of the genus *Paramegateuthis*, in particular, to *P. parabajosicus* Nalnjaeva in Sachs et Nalnjaeva, 1975. They have nothing to do with the species described above.

Specimens collected from the lower part of the Sokur quarry section (interval 120–100 cm below the “belemnite level”; Plate II, fig. 2) differ from specimens that come from the levels nearer the “belemnite level” (interval 0–20 cm below this level; Plate II, figs. 3–4) in their stronger compression ( $LL/DV = 0.84\text{--}0.89$  instead of  $0.90\text{--}0.94$ , see Fig. 3a), being

**Plate II.** (1–5) *Barskovisella bajosicus* (Ivanova, 1959): (1) specimen VSGM ISS/40, Pletnyovka quarry, tailings (Bed 3 or 4); (2) specimen VSGM SOK/43, Sokur quarry, 120 cm below the “belemnite level”; (3) specimen VSGM SOK/116, Sokur quarry, talus (3c—alveolar view, 3d—longitudinal section, polished); (4) specimen VSGM SOK/61, Sokur quarry, “belemnite level”; (5) specimen VSGM SOK/45, juvenile rostrum, Sokur quarry, 120 cm below the “belemnite level”; (6, 7) *Barskovisella barskovi* sp. nov.: (6) holotype VSGM SOK/101, Sokur quarry, 40 cm above the “belemnite level”; (7) specimen VSGM BP-09682, Sokur quarry, ?upper belemnite level [unfigured specimen of *Paramegateuthis* cf. *manifesta* in Mitta et al., 2004, no. CR-2800]; (8–11) *Barskovisella gracilis* sp. nov.: (8) specimen VSGM ISS/45, Pletnyovka quarry; (9) holotype VSGM ISS/11, Pletnyovka quarry; (10) specimen VSGM SOK/117, specimen with traces of lifetime injuries, Sokur quarry; (11) specimen VSGM ISS/44, Pletnyovka quarry; all specimens without precise positions within the sections.

Plate II



similar in this character to the ancestral species *B. variabilis* sp. nov. Simultaneously, some specimens coming from levels near the “belemnite level” (Plate II, fig. 4; Mitta et al., 2014, figs. 7.4, 7.8) have shortened slightly compressed rostra similar to those of the next species in the lineage—*B. barskovi* sp. nov. Since the vertical replacement of the more compressed specimens by less compressed specimens fits well the main morphological trend of *Barskovisella* gen. nov., this can mean that the species *B. bajosicus* in the Sokur quarry can be split into two separate taxa (Fig. 3a) by the rostrum compression rate, while to the naked eye these varieties are practically indistinguishable. However, finds nominally coming from the “belemnite level” (Mitta et al., 2004), in particular, the paratype of *Nannobelus bellus* (specimen VSGM BP-09667; Mitta et al., 2004, pl. 3, fig. 5), also show considerable compression (LL/DV = 0.88). Judging from the excellent preservation of its surface, this specimen, like the holotype of *N. bellus*, is unlikely to originate from the “belemnite level.” Taking into account that some other specimens in Barskov’s set are also unlikely to have come from the “belemnite level” (see above), the origin of these belemnites from the lower levels of the section cannot be excluded. Currently, there is insufficient material available to the author to substantiate the taxonomic separation of specimens from the “upper” and “lower” parts of the Sokur quarry section below the “belemnite level”. Note that, judging from a single find of an advanced-looking specimen with LL/DV = 0.91 (VSGM ISS/40, Plate II, fig. 1) coming from the interval of Beds 3–4 in the Pletnyovka quarry, which certainly corresponds to the lower part of the total stratigraphic range of *B. bajosicus*, the presumed differences are statistical, and therefore the above morphs are distinguishable as subspecies at the most.

The late variety of the described species, which is characterized by a somewhat shortened rostrum and sometimes rounded-square cross section (Plate II, figs. 1e, 4e), is quite similar to specimens from Switzerland figured by Gilliéron (1873) as “*Belemnites Escheri* Mayer, 1863.” Judging from the list of co-occurring ammonite species (Gilliéron, 1873, p. 75), these finds have late Bajocian–early Bathonian age. The original description of this species (Mayer, 1863) does not contain illustrations of the rostra, and the precise age of the type series also remains unknown; it can be even early Bajocian (compare Riegraf, 1995, p. 49 and Riegraf et al., 1998, p. 213). Taking into account the considerably smaller size of Gilliéron’s specimens compared to the size indicated by Mayer, the assignment of Gilliéron’s and Mayer’s specimens to the same species is questionable. This also means that the name *Belemnites Escheri* Mayer, 1863 can be considered as a nomen dubium, and in that case, it is not a subjective senior synonym of *Mesoteuthis bajosicus* Ivanova, 1959.

Six rostra found in the tailings of the Pletnyovka quarry, certainly fall into the variability range of

*B. bajosicus*. Judging from the matrix available, in two cases, they originate from Bed 2, and the alveolus of one more specimen (Plate II, fig. 1) was filled with yellow sand, lenses of which are present in the section starting from Bed 3 and upwards. In the Sokur quarry, *B. bajosicus* in its entire range is associated with numerous Boreal belemnites of the family Cylindroteuthididae (genus *Pachyteuthis*); however, not a single rostrum of this family has been found in the Pletnyovka quarry. This means that the first appearance of *B. bajosicus* precedes the beginning of wide immigration of cylindroteuthidids to the territory of the Russian Plate.

**M a t e r i a l.** 8 rostra from the Sokur quarry: 6 from the interval 0–120 cm below the “belemnite level,” 2 from the talus; 6 rostra from the tailings of the Pletnyovka quarry [talus of Beds 2–4].

*Barskovisella barskovi* sp. nov.

Plate II, figs. 6, 7

*Brachybelus breviformis*: Pugaczewska, 1961, pp. 142–143, pl. IV, fig. 12 (=Pugaczewska and Kopik, 1980, pl. 61, fig. 1; Pugaczewska and Kopik, 1988, p. 161, pl. 61, fig. 1).

*Nannobelus parabellus*: (pars) Barskov in Mitta et al., 2004, pp. 19–20, pl. 3, fig. 8 [only this specimen].

*Paramegateuthis* cf. *manifesta*: (pars) Barskov in Mitta et al., 2004, pp. 22–23 [only unfigured specimen CR-2800].

*Paramegateuthis parabella* (Barskov): (pars) Dzyuba in Mitta et al., 2014, fig. 7.5 [only this specimen].

**E t y m o l o g y.** As for the genus.

**H o l o t y p e.** VSGM SOK/101; Sokur quarry, 40 cm above the “belemnite level”; O. besnosovi Zone, provisional O. cf./aff. besnosovi Biohorizon of Gulyaev (in press).

**D i a g n o s i s.** *Barskovisella* with a rostrum elongation  $E = 120–150\%$  with compression  $LL/DV \geq 0.92$ .

**D e s c r i p t i o n.** The rostrum is very short ( $E = 120–150\%$ ), sharply conical in both profile and outline. The apex in adult specimens is slightly shifted dorsally. The dorsal and lateral margins are weakly convex; the ventral margin is strongly convex. The transverse section is rounded-trapezoid, laterally compressed ( $LL/DV = 0.92–0.99$ ), with flattened lateral sides, inclined dorsally. Near the posterior end, the cross section is rounded. No apical grooves are present.

The alveolus occupies approximately 2/3 of the rostrum length, is slightly compressed laterally, and its angles are  $\beta$  (dv) =  $29^\circ$  and  $\beta$  (ll) =  $27.5^\circ–28^\circ$ ; the apex is slightly displaced to the ventral side.

**D i m e n s i o n s a n d r a t i o s.** See Table 2.

**V a r i a b i l i t y.** Insufficient data.

**C o m p a r i s o n.** This species is distinguished from all species of the genus, including its immediate ancestor *Barskovisella bajosicus*, by a very short rostrum ( $E \leq 150\%$  in adults). The homeomorphically similar late Aalenian–early Bajocian species *Brevi-*

*belus gingensis* (Voltz, 1830) (see Schlegelmilch, 1998, pl. 13, figs. 7, 8) is almost indistinguishable.

**Occurrence.** Lower Bathonian of the Volga region; *Oraniceras besnosovi* ammonite zone, O. cf./aff. *besnosovi* Biohorizon and the interval above, not characterized by ammonite finds; Poland (vicinity of Krakow).

**Remarks.** Although there is only one rostrum in the collection, its assignment to a separate species is certain. As it was found in situ above the “belemnite level,” it fits very well the general evolutionary trends of the genus *Barskovisella* gen. nov. (Fig. 3) as a terminal member of the lineage having the shortest rostrum in the lineage. There are two mentions in the literature of megateuthidid occurrences above the “belemnite level”—one of these is *Barskovisella renegata* sp. nov. (Mitta et al., 2014, fig. 7.7; see below), and the second is a juvenile rostrum (Mitta et al., 2014, fig. 7.5), which evidently belongs to a described species. This rostrum differs from *B. bajosicus* at equivalent growth stages (Plate II, fig. 3) in the slightly less elongated rostrum, which has only slight compression.

All characteristics of the described species are also shared by the paratype of *Nannobelus parabellus* (Mitta et al., 2004, pl. 3, fig. 8) and one of the unfigured specimens of *Paramegateuthis* cf. *manifesta* cited in the same paper. Although both of these specimens allegedly come from the “belemnite level,” they can in fact come from the “upper belemnite level” sensu Mitta et al., 2011, which was not recognized separately, although it is also shown in the lithological log (Mitta et al., 2011, Fig. 2). This level is just above the reference “belemnite level” and thus can be correlated by position to some extent with our find, although a different interpretation is possible—i.e., *B. barskovi* sp. nov. starts from the true “belemnite level.”

The rostrum described by Pugaczewska (1961) as *Brachybelus breviformis* (Voltz, 1830) from the no longer existing Trzebionka quarry in Poland may belong to this species. The Polish specimen probably has even a shorter rostrum than the holotype of *B. barskovi* sp. nov. The age of this find is indicated as “Bathonian” without further specification. Some of the accompanying belemnites originally also classified as Bathonian, at first glance, suggest the Early Jurassic age of the deposits because they were assigned to *Rhabdobelus exilis* (d’Orbigny, 1842) [sole occurrence, this species is currently dated as late Toarcian] and *Gastrobelus ventroplanus* (Voltz, 1830) [multiple finds, this species is currently dated as Pliensbachian]. However, the Early Jurassic age of all these finds, e.g., cited in the publications of subsequent authors (Weis et al., 2015), does not correspond to reality. Firstly, *G. ventroplanus* is identified incorrectly: figured rostra are distinctly fusiform with a subcentral axial line and ventral groove (Pugaczewska, 1961, pl. 5, fig. 7), which undoubtedly suggests their affinity with the genus *Hibolithes* and accordingly the post-Aalenian age. Secondly, *Rhabdobelus exilis* is indeed a late Toarcian species, but other

species of this genus were recorded in the Aalenian—lower Bajocian (Weis et al., 2015) and occur in higher horizons in the Middle Jurassic (Ippolitov, unpublished data). Thirdly, no marine Lower Jurassic is recorded in this region (Mappa..., 2000) and the succession of the normal-marine deposits begins from the early Bajocian *Otoites sauzei* Zone (Kopik, 1998). The ore-bearing formation of the Częstochowa Clay, siderites from which were quarried in the 20th century and which yielded *Brachybelus breviformis* (Pugaczewska, 1961, p. 111), is of late Bajocian—Bathonian age (Garantiana Zone and above; Kopik, 1998; Leonowicz, 2013; Matyja and Wierzbowski, 2000). Considering that the Polish rostrum lacks apical grooves, which is a definitive characteristic of *Barskovisella* gen. nov., and also the absence of Lower Jurassic cephalopods in the assemblage, except for *Rhabdobelus* mentioned above, the early Bathonian age of the Polish find is very likely to be correctly determined and indicated.

**Material.** 1 complete well preserved rostrum from the Sokur quarry, 40 cm above the “belemnite level.”

*Barskovisella gracilis* sp. nov.

Plate II, figs. 8–11; Plate III, fig. 8a

**Etymology.** From the Latin *gracilis* (graceful).

**Holotype.** VSGM ISS/11; Penza region, Pletnovka quarry, from tailings; lower Bathonian, *Oraniceras besnosovi* ammonite Zone, O. sp. nov. A/O. sp. nov. B Biohorizon (after Gulyaev and Ippolitov, 2017).

**Diagnosis.** *Barskovisella* of distinctly conical shape both in profile and in outline, with elongation  $E = 282\text{--}343\%$ , and compression  $LL/DV = 0.92\text{--}0.95$ .

**Description.** The rostrum is medium-sized, short to slightly elongated ( $E = 283\text{--}343\%$ ), conical both in profile and in outline. The posterior end is strongly attenuated and is slightly displaced dorsally. The lateral margins are almost straight, weakly convex; the dorsal and ventral margins are straight in the alveolar region. At the transition to the apical region, the dorsal margin becomes concave, and the ventral margin becomes convex. The cross section is rounded, laterally compressed ( $LL/DV = 0.92\text{--}0.93$ ), with weakly flattened lateral sides, inclined dorsally. Near the posterior end, the cross section is rounded. No apical grooves are present.

The alveolus occupies approximately 2/5–1/2 of the rostrum length and is hardly noticeably compressed laterally; its angles are  $\beta$  (dv) =  $26^\circ\text{--}28^\circ$  and  $\beta$  (ll) =  $25^\circ\text{--}26^\circ$ ; the alveolar tip is slightly shifted ventrally.

**Dimensions and ratios.** See Table 2.

**Variability.** Specimens in the collection vary in the degree of attenuation of the posterior end.

**Comparison.** *B. gracilis* sp. nov. differs from the apparently co-occurring *B. issae* sp. nov. and *B. variabilis* sp. nov. in the conical shape of the rostrum

in outline, less prominent compression ( $LL/DV \geq 0.92$  in *B. gracilis* sp. nov. instead of 0.73–0.86 in *B. issae* sp. nov. and 0.73–0.89 in *B. variabilis* sp. nov.), and very weak flattenings on the lateral sides. It is different from *B. parabella*, which has similar proportions of the rostrum, in the subcentral rather than dorsally displaced apex and in the slightly more prominent elongation ( $E = 282\text{--}343\%$  instead of 207–257% in *B. parabella*). *B. bajosicus* and *B. barskovi* sp. nov. have less elongated rostra (usually  $E < 220\%$ ) with pronounced flattenings on the lateral sides.

**Occurrence.** Lower Bathonian of the Volga region; Oraniceras besnosovi Zone, O. sp. nov. A–O. sp. nov. B biohorizons (after Gulyaev and Ippolitov, 2017); the exact range is unknown.

**Remarks.** Among all species of the genus *Barskovisella* gen. nov., this species is distinguished by a slightly larger size, and although no juveniles were found, they are expected to be indistinguishable from those of *B. variabilis/issae* spp. nov.

In this paper, the described species is interpreted as a divergent taxon in relation to the main *Barskovisella* lineage, originating from *B. variabilis* sp. nov. The connection with the latter species is supported, apart from the similarity of the main parameters, by comparable phragmocone angles (Fig. 3c).

All finds come from the tailings. The preservation of the holotype from the Pletnyovka quarry indicates the origin from Bed 1 or 2. The only specimen found in the tailings of the Sokur quarry by the preservation of its external surface differs from all other finds from this locality. As no morphologically similar finds were reported by any of the authors, it is suggested that this specimen comes from the excavated lower part of the section inaccessible in the 2000s (like some ammonites; see Mitta and Seltzer, 2002; Mitta et al., 2004).

**Material.** 4 rostra: 3 from the tailings of the Pletnyovka quarry, 1 from the tailings of the Sokur quarry (coll. A.V. Guzhov).

***Barskovisella parabella* (Barskov in Mitta et al., 2004)**

Plate III, figs. 1–4

*Nannobelus parabellus* sp. nov.: (pars) Barskov in Mitta et al., 2004, pp. 19–20, pl. 3, fig. 7 [this specimen and unfigured specimen CR-2795; non fig. 8 = *B. barskovi* sp. nov.].

*Paramegateuthis* cf. *manifesta*: (pars) Barskov in Mitta et al., 2004, pp. 22–23, pl. 3, figs. 3, 4 [only these specimens].

*Paramegateuthis parabellus*: (non) Dzyuba in Mitta et al., 2014, figs. 7.4, 7.8 [= *B. bajosicus* (Ivanova)], 7.5 [= *B. barskovi* sp. nov.].

**Diagnosis.** *Barskovisella* of subconical shape both in profile and outline, with apex strongly displaced to dorsal side, with rostrum elongation  $E = 207\text{--}257\%$ , weakly compressed ( $LL/DV = 0.91\text{--}0.98$ ).

**Description** (see also Mitta et al., 2004, pp. 19–20). The rostrum is short ( $E = 207\text{--}257\%$ ; in large specimens 230–257%), sharply conical both in profile and in outline. The apex is completely shifted dorsally. The ventral and lateral margins are distinctly convex; the dorsal margin is straight over most of its length and is slightly concave only in the attenuated apical part. The cross section is rounded, weakly laterally compressed ( $LL/DV = 0.91\text{--}0.93$  in young specimens, 0.98 in adult specimen VSGM SOK/118), with slightly flattened lateral sides, hardly noticeably inclined upwards. The cross section becomes rounded near the posterior end. Apical grooves are absent.

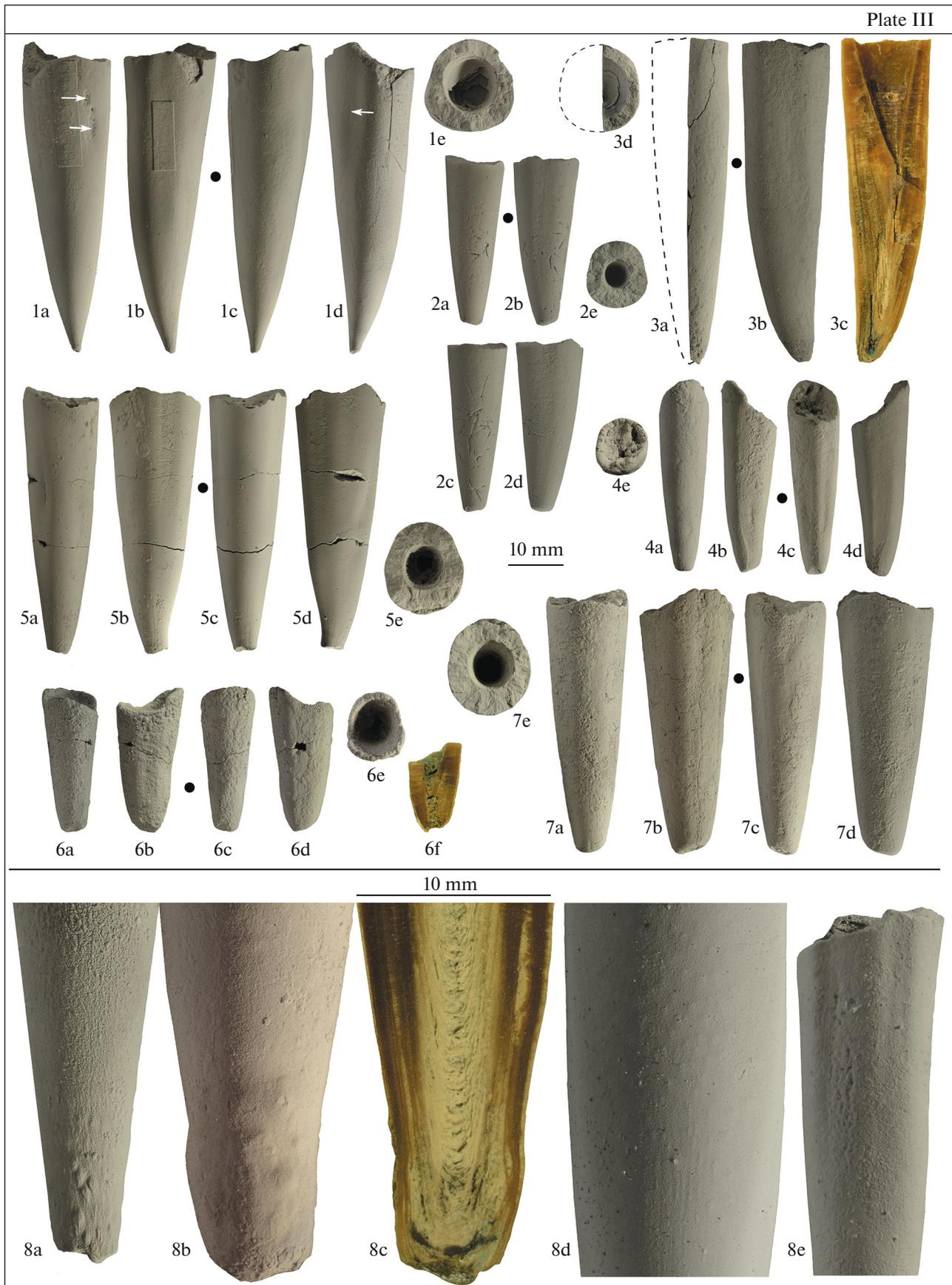
The alveolus is approximately 2/5 of the rostrum length;  $\beta$  (dv) = 27°–28° and  $\beta$  (ll) = 26°–27°; the apex is slightly shifted ventrally ( $R_V/DV' = 0.37$  in specimen VSGM SOK/118).

**Dimensions and ratios.** See Table 2.

**Variability.** Juveniles show a slightly stronger compression and slightly less elongation, which makes difficult their separation from the co-occurring *B. bajosicus* (Fig. 3b). These species are distinguished only by the displacement of the apex to the dorsal side in *B. parabella*, which is remarkable at all growth stages.

**Comparison.** This species differs from other species of the genus in the distinct conical shape with the dorsally shifted apex; the latter is the principal definitive character of the described species. It also differs from the co-occurring *B. bajosicus* by in average longer postalveolar region (207–257% instead of usually 195–220% in *B. bajosicus*), but young specimens of both species are indistinguishable in their main characteristics. The second similar species is *B. gracilis* sp. nov., from which the described species differs, apart from the dorsally displaced apex, in the slightly shorter postalveolar region ( $E = 207\text{--}257\%$  instead of 282–

**Plate III.** (1–4) *Barskovisella parabella* (Barskov in Mitta et al., 2004), Sokur quarry: (1) holotype VSGM BP-09670 [figured by Mitta et al., 2004, pl. 3, figs. 3a–3c], arrows show lifetime predator bites; (2) VSGM SOK/104, young specimen, almost indistinguishable in parameters from *B. bajosicus*; from talus; (3) specimen VSGM SOK/118, from talus (3c—longitudinal polished section, right-side view; 3d—alveolar view); (4) specimen VSGM BP-09720 [figured by Mitta et al., 2004, pl. 3, figs. 3a–3c as *Paramegateuthis* cf. *manifesta*; CR-2786], “belemnite level”; (5–7) *Barskovisella renegata* sp. nov., Sokur quarry: (5) specimen VSGM SOK/50, specimen with lifetime injuries; 100 cm below the “belemnite level”; (6) specimen VSGM SOK/100, juvenile specimen with eroded apical zone; “belemnite level”; (6f) longitudinal polished section; left-side view; (7) holotype VSGM SOK/85, from talus (“belemnite level”); (8) details of morphology of *Barskovisella* spp. ( $\times 3.5$ ): (8a) apical part of *Barskovisella gracilis* sp. nov. with inflations, dorsal view (entire specimen shown in Plate II, fig. 9c); (8b) apical part of the rostrum of *Barskovisella issae* sp. nov. with inflations, right-side view; (8c) the same, polished section, left-side view (entire specimen shown in Plate I, figs. 7b and 7f); (8d) surface ornamentation of *B. variabilis* sp. nov. on the dorsal side in the middle of the postalveolar part of the rostrum (entire specimen shown in Plate I, fig. 9c); (8e) lateral lines of *Barskovisella* cf. *pseudoishmensis* sp. nov. (entire specimen shown in Plate I, fig. 3d).



343% in *B. gracilis* sp. nov.) and in the slightly less compression in adults.

**Occurrence.** Lower Bathonian of the Volga Region; Oraniceras besnosovi Zone, O. besnosovi Biohorizon (upper part)/Arcticoceras ishmae Zone, A. excentricum Biohorizon (upper part); possibly also occurring below that level.

**Remarks.** Unluckily, the selected holotype is represented by a specimen bearing healed lifetime injuries in the alveolar region (Plate III, figs. 1a, 1d), and this fact was completely overlooked by the authors of the original description. Therefore the degree of compression  $LL/DV = 102\%$  in the holotype is distorted, as well as the symmetry, but nevertheless the main characters of the rostrum allow comparison with other specimens. The find of a similar adult rostrum (Plate III, fig. 3) shows that the complete shift of the apex of the rostrum to the dorsal side and a relatively isometric cross section observed in the holotype are not the characters resulted from the injury. Also, the designation of a pathological specimen as nomenclatural type, if it is not originally considered as teratological (Art. 1.3.2), conforms to the ICZN Code.

Except for the holotype, all specimens previously cited in the literature under the specific name *parabell*a do not in fact belong to this species. However, both rostra with pronounced dorsolateral grooves figured by Barskov as *Paramegateuthis* cf. *manifesta* (Mitta et al., 2004, pl. 3, figs. 3, 4; this paper, Plate III, fig. 4) belong to this species. Their original assignment to the genus *Paramegateuthis* was later supported by T.I. Nalnjaeva (in Meledina et al., 2009) and initially by O.S. Dzyuba (Mitta et al., 2012), who also suggested that *P.* cf. *manifesta* should be described as a separate new species. No similar rostra with grooves were found in subsequent years. The reexamination of Barskov's original material showed that the dorsoventral "grooves" do not closely approach the apex of the rostrum (Plate III, fig. 4c) and look like wide and shallow depressions rather than typical incised apical grooves of *Paramegateuthis*. Despite these differences, they can be considered as partial recapitulation of ancestral characters in *Barskovisella* gen. nov. At the same time, in the degree of elongation and compression and characteristic shift of the posterior end to the dorsal side, these specimens are well comparable with the holotype of *B. parabell*a.

The range of variability of *B. parabell*a in a diagram (Fig. 3b) overlaps with that of *B. bajosicus*. Although the total number of occurrences of the described species is low, its specific status is substantiated by occurrences in the "belemnite level" ("*Paramegateuthis* cf. *manifesta*" sensu Barskov in Mitta et al., 2004 clearly belongs to this level as indicated by the preservation), where I found only the late morphotype of *B. bajosicus*, which has a shortened rostrum, strongly differing from that of *B. parabell*a.

The main differences of *B. parabell*a from the co-occurring *B. bajosicus* are essentially the same as for the older pair of *B. gracilis* sp. nov.—*B. issae/variabilis* spp. nov.: less compressed cross section with narrow lateral flattenings and regularly conical general shape without clearly separated apical region. This means that *B. gracilis* sp. nov. and *B. parabell*a either form a separate lineage within the genus *Barskovisella*, morphogenesis of which was parallel to the lineage *B. issae* sp. nov.—*B. variabilis* sp. nov.—*B. bajosicus*—*B. barskovi* sp. nov., or are complementary dimorph pairs to co-occurring species *B. issae/variabilis* ssp. nov. and *B. bajosicus*. More extensive material is needed to solve this question. However, even in the latter case, the consideration of sexual dimorphs as separate species is justified: characters in dimorphs evolve at a different rate, and in the future, this could help to generate parallel infrazonal scale.

**Material.** 2 rostra from the Sokur quarry (from talus, vicinity of the "belemnite level").

*Barskovisella renegata* sp. nov.

Plate III, figs. 5–7

*Paramegateuthis* cf. *pressa*: Barskov in Mitta et al., 2004 (?pars), p. 22, Plate 3, figs. 1–2 [only these specimens].

*Paramegateuthis bella*: Dzyuba in Mitta et al., 2014, figs. 7.6, 7.7.

*Paramegateuthis*: Ippolitov and Gulyaev, 2017, p. 79.

**Holotype.** VSGM ISS/85, Saratov, Sokur quarry, talus [state of preservation as in the "belemnite level"]; lower Bathonian, Oraniceras besnosovi ammonite zone and (?) biohorizon.

**Etymology.** From the Russian "renegat" (renegade; rebel), as this species tends to reacquire morphology characteristic of the ancestral genus *Paramegateuthis*, to which these specimens were previously erroneously assigned by the present author (Ippolitov and Gulyaev, 2017).

**Diagnosis.** *Barskovisella* with a distinctly conical rostrum; elongation  $E = 269–293\%$ , lateral compression along the entire length ( $LL/DV = 0.87–0.89$ ), up to the apical region.

**Description.** The rostrum is medium-sized, moderately elongated ( $E = 269–293\%$  in adults), conical in both profile and outline. The apex is subcentral. The ventral and lateral margins are weakly convex, the dorsal margin is straight over most of its length, and only near the posterior end is convex. The cross section is laterally compressed along the entire length ( $LL/DV = 0.87(0.81?)–0.89$ ) with slightly narrower dorsal side, with narrow longitudinal flattenings, occurring above and below the midpoint of the lateral sides. The upper flattenings are inclined to the dorsal side. One of the specimens (VSGM SOK/50; Plate III, fig. 5) shows the flattenings formed by the fusion of three lateral lines: one of these occurs below the lateral shoulder, and the other two, which run almost parallel to each other, are above it. The latter flattenings run up to the apex of the rostrum and are transformed into

indistinct apical dorsoventral flattenings. The presence of the true, deeply incised dorsolateral grooves is not observed. A distinct short shallow ventral groove (Plate III, fig. 7a), apparently reaching 6–8 mm in length, is well discernible near the apex of one of the specimens both in adult and at early growth stages.

The alveolus is approximately 2/5 of the rostrum length; its angle  $\beta$  (dv) = 26°–29° and  $\beta$  (ll) = 23.5°; the alveolar tip is slightly shifted ventrally ( $R_V/DV' = 0.40$  in specimen VSGM SOK/100).

**Dimensions and ratios.** See Table 2.

**Variability.** Insufficient material.

**Comparison.** The retention of the clear lateral compression up to the apical region is a definitive character of the described species, distinguishing it from all representatives of the genus *Barskovisella* gen. nov. The described species also differs from the most closely similar (possibly ancestral) species *B. bajosicus* in the slightly more elongated rostrum ( $E \geq 269\%$  instead of  $E \leq 244$  in *B. bajosicus*) and distinctly conical shape in profile. *B. renegata* sp. nov. differs from *B. variabilis* sp. nov., with which it overlaps in the main ratios, in the conical shape of the alveolar region in profile (the rostrum in *B. variabilis* sp. nov. is subconical or even subcylindrical). The early species *B. pseudoishmensis* sp. nov., the lateral flattenings of which, as in *B. renegata* sp. nov., can be traced far posteriorly, has a much more elongated rostrum.

The species *Paramegateuthis timanensis* (Gustomesov, 1960) is convergently similar in the general shape. *B. renegata* sp. nov. is readily distinguished from it by the presence of prominent lateral flattenings in the alveolar part of the rostrum characteristic of all *Barskovisella*, by the absence of clearly pronounced dorsolateral grooves near the apex, and by the ventral side being wider than the dorsal at the anterior end of the rostrum (in *P. timanensis* their relation is inverse).

**Occurrence and age.** Sokur quarry; lower Bathonian, O. besnosovi/A. ishmae Zone, O. besnosovi/A. excentricum—O. cf./aff. besnosovi biohorizons.

**Remarks.** This species in its general appearance and main ratios is similar to *B. bajosicus* and at first glance can be interpreted as an extreme “archaic” variety of the latter (Fig. 3). However, the in situ find of *B. renegata* sp. nov. considerably above the “belemnite level” (Mitta et al., 2014, fig. 7.7), stratigraphically corresponds to the next member of the main lineage of *Barskovisella* (*B. barskovi* sp. nov.). In addition, the conical shape of *B. renegata* sp. nov. does not agree with the characteristics of *B. variabilis* sp. nov. (ancestral to *B. bajosicus*), which in the anterior region is subconical to subcylindrical. All this definitely indicates the divergent origin of the newly described species in relation to the main *Barskovisella* lineage. Apparently, *B. renegata* sp. nov. originated from the early morphotypes of *B. bajosicus*.

*B. renegata* sp. nov. should apparently include rostra figured by Barskov (Mitta et al., 2004, pl. 3, figs. 1–2) as *Paramegateuthis* cf. *pressa* and resembling the described species by the profile. The compression of these rostra is increased owing to the abrasion of the lateral sides, although they were considerably compressed originally, up to the posterior end.

**Material.** 4 rostra from the Sokur quarry: 3 from the interval 0–100 cm below the “belemnite level,” 1 (holotype) from the talus, but the latter likely originates from the “belemnite level.”

## LOWER BATHONIAN BIOSTRATIGRAPHY OF THE VOLGA REGION USING MEGATEUTHIDIDS

Belemnite-based subdivisions for the Bathonian deposits of the Russian Plate were introduced for the first time in the most recent version of the Unified Scheme of Jurassic Deposits of the East European Platform (*Unifitsirovannaya...*, 2012). They include the “beds with *Pachyteuthis* sp., *Paramegateuthis* sp.,” which in fact correspond to the whole interval containing belemnites in the section of the Sokur quarry. Slightly later, Dzyuba proposed more detailed subdivisions in the rank of “beds with...” correlated with the ammonite scale (Mitta et al., 2014), but only the members of the genus *Pachyteuthis* Bayle, 1878 from the family *Cylindroteuthididae* were used as index taxa.

Material collected in the Pletnyovka and Sokur quarries suggests the possibility of an alternative biostratigraphic subdivision based on the endemic genus *Barskovisella* gen. nov. (Fig. 4). This subdivision also covers a lower interval of the lower Bathonian succession still lacking *Cylindroteuthididae*. The new belemnite-based units are described below.

### *Beds with Barskovisella, nov.*

**Index.** Genus *Barskovisella* gen. nov.—entire range of vertical distribution.

**Stratotype.** Pletnyovka quarry (lower part of the unit), Sokur quarry (upper part of the unit).

**Belemnite assemblage.** *Barskovisella* spp.; in the upper part, *Pachyteuthis* spp. (list of species see in the second part of this study).

**Lower boundary.** FAD of *Barskovisella*.

**Upper boundary.** LAD of *Barskovisella*.

**Age and correlation.** Lower Bathonian. Approximately corresponds to the *Oraniceras besnosovi* ammonite zone (starting from the O. sp. nov. A Biohorizon), but the exact positions of the boundaries of both biostrata in relation to one another are yet to be established.

**Occurrence.** Volga Region (Penza, Saratov, ?Volgograd regions).

**Localities.** Pletnyovka quarry, Sokur quarry.

Substage	Ammonite units (Gulyaev and Ippolitov, 2017; Gulyaev, in press)		Belemnite units (present study)	
	Zones	Biohorizons	Beds	Biohorizons
Lower Bathonian	ISHMAE	No finds		
		O. cf./aff. besnosovi	Beds with Barskovisella	B. barskovi
		O. besnosovi		A. excentricum
		O. sp. nov. B		B. variabilis
	BESNOSVI	O. sp. nov. A		B. issae
		O. scythicum		No finds
		O. mojarowskii		

**Fig. 4.** Zonal and infrazonal scales of the lower Bathonian of the Volga region based on belemnite genus *Barskovisella* gen. nov. and its correlation with the parallel ammonite biostrata. A.—*Arcticoceras*, O.—*Oraniceras*, B.—*Barskovisella*.

**Biohorizons.** A well-established evolutionary sequence of the chronospecies of the main lineage of the genus *Barskovisella* gen. nov. allows the recognition of four successive biohorizons corresponding to the ranges of their index species.

**a. *B. issae* Biohorizon, nov.** Stratotype—Pletnyovka quarry, interval 50–100 cm above the base of the Bed 1. Corresponds to the lower part of the O. sp. nov. A ammonite biohorizon (after Gulyaev and Ippolitov, 2017).

**b. *B. variabilis* Biohorizon, nov.** Stratotype—Pletnyovka quarry, interval 150–170 cm above the base of the Bed 1 (transitional forms from the ancestral species *B. issae* sp. nov. occur at 150 cm above the base of Bed 1). Corresponds to the upper part of the O. sp. nov. A ammonite biohorizon (after Gulyaev and Ippolitov, 2017).

**c. *B. bajosicus* Biohorizon, nov.** Stratotype—Sokur quarry, interval 120–0 cm below the “belemnite level.” Corresponds to the O. sp. nov. B (?)—O. besnosovi/A. excentricum ammonite biohorizons (after Gulyaev, in press; Gulyaev and Ippolitov, 2017).

**d. *B. barskovi* Biohorizon, nov.** Stratotype—Sokur quarry, interval 40–190 cm above the “belemnite level.” Corresponds to the upper part of the O. besnosovi ammonite zone (provisional O. cf./aff. besnosovi Biohorizon (after Gulyaev, in press) and higher part of the succession, not characterized by ammonite finds).

Taking into account finds of the index taxa of the two upper biohorizons in Europe (Gilliéron, 1873; Pugaczewska, 1961; see above), some of the recognized infrazonal strata apparently have a considerable interregional correlative potential.

Additionally, a unit containing the most archaic species of the genus—*B. pseudoishmensis* sp. nov.—can also be provisionally considered as a basal biohorizon of the succession. However, in situ finds of the index species are needed to confirm that, as the provisional index can potentially co-occur with *B. issae* sp. nov. or *B. variabilis* sp. nov. It seems possible to recognize in the future parallel biohorizons on the basis of the *B. gracilis* sp. nov.—*B. parabella* lineage; however, the stratigraphic distributions of these taxa and their nature (dimorphism, independent lineage, or extreme examples of variability) still remain unresolved.

## CONCLUSIONS

A brief summary is provided.

1. The revision of belemnites of the family Megateuthididae from the lower Bathonian deposits of the Volga region shows the presence of eight species (six new) belonging to a single genus.

2. Small-sized early Bathonian megateuthidids from the Volga region previously identified as *Nannobelus* (Mitta and Seltzer, 2002; Mitta et al., 2004), *Brevibelus* (Mitta et al., 2012), and *Paramegateuthis* (Seltzer and Ivanov, 1997; Mitta et al., 2014) are neoenemics of the Russian Plate, originating from the Boreal-Arctic genus *Paramegateuthis*, and are recognized in the present paper as a separate genus *Barskovisella* gen. nov. On the basis of the analysis of the vertical distribution of the characters, the main evolutionary trends in this lineage are recognized.

3. A new stratigraphic scheme for the lower Bathonian deposits of the Volga region is developed on the basis of belemnites of the genus *Barskovisella* gen. nov. The scheme includes four successive infrazonal strata (biohorizons) in the interval of the Oraniceras besnosovi ammonite zone (beginning from the O. sp. nov. A Biohorizon), joined together into the beds with *Barskovisella*.

The most important methodological result of this study is that the proposed infrazonal subdivisions based on belemnites (biohorizons corresponding to the ranges of the chronospecies of the genus *Barskovisella* gen. nov.) are at least as detailed as the ammonite biostrata for the same interval. The phylogenetic study which formed the basis for their recognition not only allows precise datings for the studied interval even on the basis of solitary finds but also has some prognostic value, predicting characters of lineage members from previously barren adjacent intervals. This suggests that, if carefully studied, belemnite rostra can be used not just as “another group” to develop a formal scale

parallel to the ammonite one, but as a system of very precise and self-reliant biostratigraphic markers.

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