

Lower Callovian of Kanev Dislocations, Cherkasy Oblast, Ukraine: Ammonites and Stratigraphy

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Abstract—The Jurassic rocks of the area of Kanev glacial dislocations (Central Ukraine) with the Bathonian coastal marine (lagoon) and the Lower Callovian normal marine sediments have been studied, the upper part of which was unknown to the predecessors. The zonal and infrazonal scale of the Lower Callovian of Kanev dislocations are elaborated by ammonites and include four zones, five subzones, and 14 biohorizons: Elatmae Zone (the upper part: *P. elatmae* and *P. vasily* biohorizons); Subpatruus Zone (the uppermost part: *Ch. saratovensis* (*G. toricelli*) Biohorizon); Koenigi Zone with the Gowerianum (*G. metorchum* and *G. gowerianum* biohorizons), Curtilobum (*G. indigestum*, *G. curtalobum*, and *G. crucifer* biohorizons), and Galilaei (*G. galilaei*, s.l. Biohorizon) subzones; Calloviense Zone with the Calloviense (*S. khvalynicum* and *S. kiselevi* biohorizons) and Enodatium (*C. enodatium planicerclus*, *C. e. enodatium*, and *C. e. aeeta* biohorizons) subzones. This scale is compared with those of European Russia and Western Europe. It is found that the base of the *Proplanulites koenigi* Zone, which was distinguished by Karitzky (1887) in the sections of the north Kanev dislocations, biostratigraphically corresponds to the base of the eponymous Zone, which was distinguished by Buckman (1913) in North Yorkshire and used in a standard scale of Europe. The ammonites of the families *Cardioceratidae*, *Kosmoceratidae*, *Perisphinctidae*, and *Macrocephalitidae* common in the Early Callovian in the East European marine basin are revised and their evolution and biogeography are analyzed. It is shown that, at the beginning of the Callovian, this vast young epicontinental basin was a “pot” of neoen endemic evolution of various groups of ammonites, which migrated from Arctic, West European, and West Tethyan biochorems. The western (Dnieper–Donets) marine area of the basin, which also includes the area of Kanev dislocations, was a main way for migration of marine organisms between the West and East European paleobiogeographic provinces. New species are described: *Paracadoceras vasily* Gulyaev, sp. nov., *Sigaloceras fundator* Gulyaev, sp. nov., and *S. kiselevi* Gulyaev, sp. nov.

Keywords: Lower Callovian, stratigraphy, evolution, biogeography, ammonites, biohorizons, Kanev dislocations

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INTRODUCTION

The Kanev dislocations are one of the most interesting geological objects of the East European platform. They are located in the middle stream of the Dnieper River, mostly, on the territory of the Kanev district of Cherkasy oblast of Ukraine. Their geological structure and origin are considered in detail in a monograph of Lavrushin and Chugunny (1982), who substantiated a model with a key role of a Pleistocene glacial cover in the formation of dislocations.

An allochthon and the Shevchenkovo Depression are distinguished within the dislocation zone (Fig. 1). The depression is mostly occupied by a valley of the Dnieper River. The allochthon, which forms a hilly

right Dnieper coast, is subdivided into the south Kanev and north Buchak-Trakhtemirov blocks. Both blocks are composed of a series of thrusts (slices) with a repeated section of mostly northwestern and sublongitudinal strike, which are complicated by reverse faults, folds, and numerous injective structure of various scale. The dislocation structure is composed of rocks of the Lower Triassic (Mirgorod Formation exposed only by boreholes), Middle Jurassic (Bajocian, Bathonian, and Callovian), Cretaceous (Albian and Cenomanian), Paleogene (mostly, Kanev, Buchak, and Kiev formations), and, to a lesser extent, Neogene and the lower part of the Quaternary.

The Middle Jurassic rocks play the most important role in the structure of Kanev dislocations. Their total

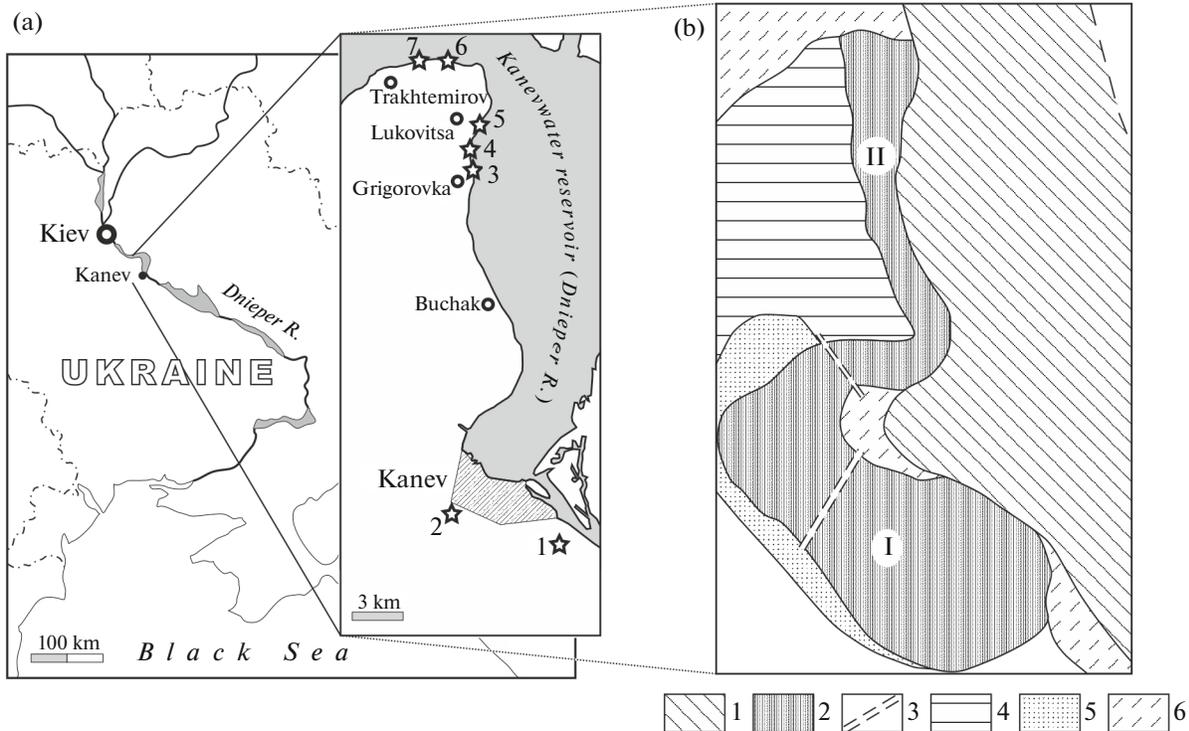


Fig. 1. (a) Position of the area of Kanev dislocations and the Lower Callovian sections studied in detail; (b) structural–geomorphological division of the area of Kanev dislocations, simplified after (Lavrushin and Chugunny, 1982; Fig. 12). Studied sections: 1, Melanchin Ravine; 2, Kostyanets Ravine; 3, Grigorovka-1 and Grigorovka-4; 4, Grigorovka-2 and Grigorovka-3; 5, Lukovitsa-1 and Lukovitsa-2; 6, Monastyrek-2; 7, Trakhtemirov. Legend: 1, Shevchenkovo depression; 2, allochthon (I, Kanev Block; II, Buchak–Trakhtemirov Block); 3, fault zone of the Kanev Block; 4, plateau overlapped by moraine and loess; 5, area of occurrence of moraine; 6, floodplain and floodplain terraces.

thickness in a dislocated state can exceed 200 m according to some estimates (Golubev et al., 1973). The oldest Bajocian continental and coastal marine rocks up to 24 m thick of the Jurassic series are exposed only by boreholes. The Bathonian includes a thick sequence of dark fine-layered clays with subordinate interlayers of silts and small-grained sands and with lenticular interlayers and horizons of siderite marl nodules in the upper part. The thickness of this sequence is estimated at up to 60–100 m and its genesis is considered sub-continental and coastal marine (Golubev et al., 1973; Lavrushin and Chugunny, 1982). The overlying Callovian rocks up to 30 m thick continue a Middle Jurassic transgressive series without evident significant unconformities. These rocks include the Lower Callovian clayey–silty, mostly, calcareous–siliceous rocks with numerous fossils of marine fauna (Gulyaev and Ippolitov, 2012; Gulyaev et al., 2013, 2014; Ippolitov and Gulyaev, 2013; Kiselev and Ippolitov, 2011; Tesakova et al., 2015).

Owing to abundance of fossils and outcrops, the Callovian sections of the area of Kanev dislocations have long been known and are classical for the southwestern part of the East European Platform. In spite of more than 150 years of study, however, the paleontological and biostratigraphic knowledge of the Kanev

Jurassic is significantly lagged behind the current European level. Before the beginning of the present-day study (the second decade of the 21st century), in fact, it remained at the level of the 1960s–1970s. For example, as to the Callovian ammonites and stratigraphy, the works of A.D. Karitzky and A.V. Paryshev of the 1880s and 1960s, respectively, were the most topical. In addition, a discussion on a stratigraphic volume of the Callovian Stage of Kanev dislocations has been conducted for almost a century. While few researchers recognized only the presence of the Lower Substage, most indicated the presence of the Middle and even Upper Callovian (see below), relying on the same sections.

The area of Kanev dislocations is one of a few places on the territory of the southwestern part of the West European Platform where the Jurassic rocks can be studied in outcrops in detail. It is important that marine Callovian sediments formed near the Pripjat (Brest) paleo Strait, which connected the vast epicontinental basins of Western and Eastern Europe. This paleo Strait was a main path of migration of marine fauna between the West European and East European paleobiogeographic provinces. Thus, the Callovian fossil complexes of this region play a key role in a detailed interregional correlation.

The authors studied the Jurassic Kanev rocks in collaboration with D.N. Kiselev (Yaroslavl State Pedagogic University (YSPU), Yaroslavl, Russia) in 2011, V.P. Gritsenko (National Museum of Natural History, National Academy of Sciences of Ukraine (NMNH NAS), Kyiv, Ukraine) in 2012, and A.I. Orudzhiev (Moscow State University, Moscow, Russia) in 2012. More than 20 natural Bathonian and Callovian outcrops were inspected. Ten Lower Callovian sections, which stratigraphically supplement and duplicate each other, were studied in detail and described (Fig. 1). The sections were sampled layer by layer and centimeter by centimeter for ammonites and belemnites and for micropaleontological studies. Thanks to the kind assistance of V.P. Gritsenko, we revised ammonites and belemnites collected in Kanev district by K.M. Feofilaktov, V.V. Reznichenko, K.A. Tsytoivich, A.V. Paryshev, and I.I. Nikitin, which are housed at the NMNH NAS. The Callovian ammonites of Kanev dislocations were also studied in collections of the Museum of the Kanev Natural Reserve (Kanev), A.D. Karitzky (Chernyshev Central Research Geological Prospecting Museum (CCRGPM), St. Petersburg), A.S. Rogovich and E.I. Eichwald (Paleontological–Stratigraphic Museum of St. Petersburg State University, St. Petersburg), and A.S. Rogovich (Vernadsky State Geological Museum, Moscow).

This work is dedicated to the detailed biostratigraphy of the Lower Callovian Kanev dislocations on the basis of study of a succession of complexes, phylogenetic links, and migrations of ammonites. The main aim was related to the elaboration of the zonal and infrazonal ammonite scale of the Lower Callovian of Kanev dislocations, which corresponds to the current international level. In addition to field works and study of museum collections, were also revised all groups of ammonites, which occur in the Lower Callovian of the East European Platform and adjacent territories. The preliminary results of studies were published previously (Gulyaev and Ippolitov, 2013; Gulyaev et al., 2014; Ippolitov and Gulyaev, 2013; Kiselev and Ippolitov, 2011; Tesakova et al., 2015; etc.).

HISTORY OF STUDY

The history of study of the Jurassic rocks of Kanev dislocations counts almost 200 years. It can conditionally be subdivided on three stages: pioneer with formation of only historically important ideas; transitional, which began from the works of A.D. Karitzky and which is related to a targeted study of the Jurassic fossils and elaboration of a stage and zonal scale of Jurassic rocks; and present-day of the last decade, which provided the improvement of stratigraphy and study of fossils of the Kanev Callovian at international infrazonal level. The development of the opinions on a strati-

graphic division of the Jurassic rocks of Kanev dislocations is shown in Fig. 2 according to the current ideas.

The pioneer stage of geological study (including Jurassic rocks) of Kanev dislocations occurred at the end of the first—the beginning of the second half of the 19th century. This period was related to the names of a French traveler-naturalist and geologist F. DuBois de Montperreux (1830s) and an outstanding Russian geologist K.M. Feofilaktov (1840s–1870s). Feofilaktov (1851) first described the outcrops of the Jurassic and younger rocks in area of the villages of Trakhtemirov, Monastyrek, and Grigorovka, as well as the Jurassic marine fossils, in particular, Callovian ammonites. His vast paleontological collection is stored at the NMNH NAS.

At the beginning of the 1860s, the primary, in particular, Jurassic, rocks of this region were inspected by A.S. Rogovich and E.I. Eichwald. In his classic work *Lethaea Rossica*, Eichwald (1865–1868) described two new Callovian *Pholadomya* bivalves and several belemnites, which were found near the village of Trakhtemirov. He also described ammonites *Ammon. Decheni* Röm. collected between the villages of Trakhtemirov and Monastyrek (Eichwald, 1865–1968, pp. 1154, 1155: esp. 1298; *Katalog...*, 2018, p. 33, pl. 24, figs. 5, 6). These ammonites (no. 2/2442–43, Paleontological–Stratigraphic Museum, St. Petersburg State University, St. Petersburg) were revised by D.B. Gulyaev and belong to the Early Callovian genus *Gowericeras* Buckman, probably, to the species *G. indigestum* (Buckman).

The next stage of the study of the Kanev Jurassic was started by Karitzky (1884, 1890, 1886, 1887). His detailed field studies of 1882–1884 were mostly conducted in the northern part of the region (Trakhtemirov, Monastyrek, and Grigorovka).¹ In the basement of the Jurassic section, he describes the ash gray shale clays with remains of crinoids (*Pentacrinus*), scales of ganoid fishes, vertebrae of reptiles, and mineralized wood. These rocks were conditionally ascribed to the Bathonian. An overlying layered sandy–clayey sequence with numerous ammonites and remains of other marine organisms was ascribed by him to the Callovian (to the its Lower Substage on the basis of ammonites). He compared this entire member of marine sediments, which is well characterized by fossils, with the *Macrocephalites macrocephalus* Zone as it was understood then by West European geologists. On the basis of the layer-by-layer collections of ammonites (Fig. 3), Karitzky divided it into two independent successive biostratigraphic zones: (a) *Cadoceras* Subhori-

¹ Unfortunately, the first vast collection and significant part of field notes of A.D. Karitzky were lost during a fire in 1883 (Karitzky, 1890, p. 98). He presented a small collection of Kanev fossils to the Geological Committee (now Karpinsky Russian Geological Research Institute, St. Petersburg); it was also examined by S.N. Nikitin and K.A. Tsytoivich.

Present work		Lithological section of the northern Kanev dislocation	Karitzky, 1887, 1890	Tsytovich, 1927, 1928	Nikitin, 1964, 1969, 1977	Paryshev, 1968 b, 1969	Pyatkova, 1985	Nikitin, 1989
STAGE(SUBSTAGE) /ZONE/Subzone								
LOWER CALLOVIAN	CALLOVIENSE	Enodatum						
		Calloviense						
	KOENIGI	Galilaeii						
		Curtilobum						
		Gowerianum						
	SUBPATRUUS							
	Cadoceras Elatmae Zone	LOWER CALLOVIAN Lower Zone		Keplerites gowerianus Zone				
ELATMAE			LOWER CALLOVIAN	LOWER CALLOVIAN	LOWER CALLOVIAN Macrocephalites macrocephalus Zone	LOWER CALLOVIAN	K.gowerianus Z. M.macrocephalus Zone	LOWER CALLOVIAN
BATHONIAN		BATHONIAN	BATHONIAN	BATHONIAN?	BATHONIAN	BATHONIAN	BATHONIAN	BATHONIAN

Fig. 2. Opinions of various researchers on the division of the Jurassic rocks of the area of Kanev dislocations. Here and in Figs. 6, 9, 12, 13, and 14, for legend, see Fig. 4.

zon (*Cadoceras Elatmae* Nik. Zone) and (b) *Perisphinctes* Subhorizon (*Perisphinctes Koenigi* Sow. Zone) (Karitzky, 1887, pp. 59–61; Karitzky, 1890, pp. 165, 166).

It is noteworthy that the standard Lower Callovian scale of Europe (*Biostratigraphie...*, 1997) currently uses the *Proplanulites koenigi* Zone, which was distinguished by Buckman (1913) in North Yorkshire,

England. The eponymous zone of Karitzky, however, has an evident priority. As shown by our study, the boundary between the ammonite zones in the north section of Kanev dislocations was established by Karitzky at the same level, which follows the boundary between the current *Ch. saratovensis* (*G. toricelli*) and *G. metorchum* biohorizons. It corresponds to the boundary of the Subpatruus and Koenigi zones of European Russia

and biostratigraphically corresponds to the basement of the basal Gowerianum Subzone of the Koenigi Zone (the base of the Kellaways Clay Member) in the vicinity of the town of Chippenham in North Yorkshire (Page, 1989). Thus, the Koenigi Zone of Karitzky has both the nomenclature priority and the biostratigraphic volume similar to the Koenigi Zone of Buckman.

On the basis of observations, Karitzky (1890) also suggested for the first time that the layers of “gray clay with *Cardioceras Chamusseti* Orb.,” “black clay with *Stephanoceras Elatmae* Nik.,” and “brown ferrous sandstone with *Cosmoceras Gowerianum* Sow.,” which were distinguished by I.I. Lahusen (1883) in various locations of the Rysan Jurassic, are not geochronologically equivalent, as was suggested by the author, but are consecutive.

At the end of the 1920s, K.A. Tsytovtich (1927, 1928) published the works dedicated to the Callovian of Kanev dislocations. These works are based on collections of the survey party of V.V. Reznichenko (1923–1925) and her own (1926). Tsytovtich criticized the opinion of Karitzky on the presence of only the Lower Callovian in the studied region. In the Kanev section of the marine Jurassic, she recognized the Lower Callovian, which is characterized by ammonites “*Cadoceras Elatmae* Nik., *Cadoceras modiolare* d’Orb., *Macrocephalites macrocephalus* Schloth.,” and the Middle Callovian with two conditional zones. The Lower Zone is characterized by “*Cosmoceras enodatum* Nikit. var. *aplanata* Tsytovt., *Hecticoceras Lugeoni* Tsytovt., and *Perisphinctes* ex. aff. *spirorbis* Neum.,” and the Upper Zone is characterized by “*Quenstedticeras henrici* Douvillé n. var. *Traktemiroviensis* Tsytovt. and *Perisphinctidae*” (Tsytovtich, 1927, pp. 2, 3). Later, Tsytovtich (1928) expanded the characteristic of the Lower and Upper zones by the species “*Keplerites gowerianus* Sow.” and “*Perisphinctes koenigi* Sow.,” respectively. It should be noted that both ammonites were considered as classical forms of the Lower Callovian from the 19th century.

The revision by Gulyaev of the collection of Reznichenko and Tsytovtich (NMNH NAS) revealed the contradicted determination of the volume and the age of the Callovian rocks. For example, judging from labels, the compressed Lower Callovian *Pseudocadoceras boreale* (Buckman), *Ps. planum* (Paryshev), “*Ps.*” ex gr. *mundum* (Sasonov), *Chamoussetia chamousseti* (d’Orbigny), and *Macrocephalites multicostatus* (Paryshev) were erroneously determined by Tsytovtich as various species of “*Quenstedticeras*” and even as “*Cardioceras*.” The representatives of the Lower Callovian genus *Toricellites* Buckman, in particular, *T. approximatus* Buckman (Plate 11, figs. 5, 6) are also present as “*Cosmoceras* n. sp. ... (gr. *C. jason*).” A small evolute microconch *Proplanulites* ex gr. *capistratus* Buckman was determined as “*Hecticoceras lugeoni* Tsytovt.” All

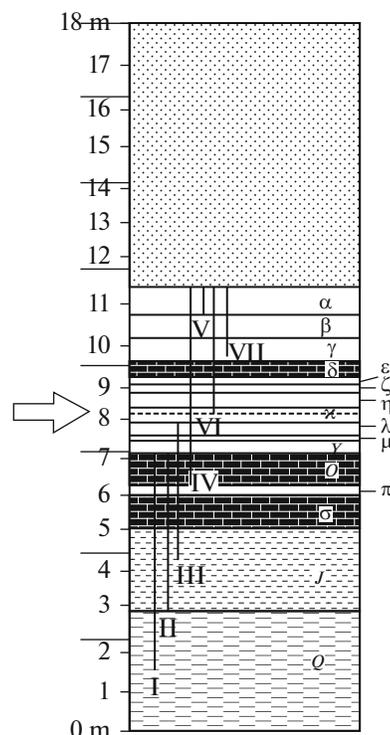


Fig. 3. Section of the Lower Callovian and “Cretaceous” (Paleogene) rocks in the northern part of the area of Kanev dislocations, near the village of Traktemirov, after (Karitzky, 1890, Fig. 7). Horizontal dashed lines, clayey rocks; empty space, siltstones; dots, “Cretaceous” sands. Vertical lines, intervals of occurrence of ammonites according to (Karitzky, 1890, p. 166, Table C): I, *Cadoceras Elatmae* Nik.; II, *Macrocephalites macrocephalus* Schl.; III, *Cardioceras Chamusseti* Orb.; IV, *Cosmoceras Gowerianum* Sow.; V, *Perisphinctes* sf. *spirorbis* Neum.; VI, *Perisphinctes Koenigi* Sow.; VII, *Cosmoceras* sf. *Galilaeii* Opp. Horizontal dashed line indicated by arrow, the boundary of *Cadoceras Elatmae* Nik. and *Perisphinctes Koenigi* Sow. zones.

this makes the conclusions of Tsytovtich on the presence of the Middle Substage of the Callovian baseless.

The mention of “*Cosmoceras enodatum* Nikit. var. *aplanata* Tsytovt.,” a species which Tsytovtich (1912) primarily described from the Callovian of Mangyshlak, is noteworthy. Unfortunately, no sample with similar label was found in the revised collection. True *Gulielmina aplanata* (Tsytovtich) was found by us in the upper part of the Calloviense Subzone in an outcrop near the village of Lukovitsa, which was not mentioned by Tsytovtich (Fig. 12; Pl. 20, figs. 5, 6). This indirectly indicates that Tsytovtich dealt both with lower and upper parts of the Lower Callovian. However, no ammonites occurring above the Gowerianum Subzone of the Koenigi Zone were found in her collection.

In 1947, an employee of VNIGNI E.I. Sokolova (Paryshev, 1969) distinguished three Substages in the

Kanev Callovian in an unpublished report. The Middle Substage was characterized by ammonites “*Keplerites calloviensis* Sow., *K. enodatum* Nik., *Kosmoceras* aff. *castor* Rein.,” etc., whereas the Upper one was characterized by “*Quenstedticeras lamberti* (Sow.)” From that period, the ideas on a three-member substage division of the Kanev Callovian were dominant in geological practice.

In 1947–1948, the Kanev Jurassic was studied by I.M. Yamnichenko (Paryshev, 1969). He established two reference sections: in the north near the village of Trakhtemirov and in the south in the Kostyanets Ravine. In both sections, Yamnichenko identified both the Lower and Middle Callovian; however, he did not support the ideas of Tsytovtch on two-zone subdivision of the latter. He indicated a transitional zone in the Kostyanets Ravine: “the Lower Callovian—the Middle Callovian.” The stratigraphic ranges of guide ammonites in the area of Kanev dislocations was considered by Yamnichenko as follows: “*Chamoussetia chamousseti* (Orb.)” (Middle and Lower Callovian), “*Keplerites gowerianus* (Sow.)” (Middle Callovian), and “*Quenstedticeras henrici* Douv.” (the lower part of the Middle Callovian). This opinion radically contradicted the ideas on the ranges of these species in Western Europe and Central Russia.

I.I. Nikitin (1964, 1969, 1977, etc.) significantly contributed to the study of the Kanev Jurassic and its fossils, first, Callovian belemnites. After Tsytovtch, probably, orienting on her determinations of ammonites, he also supports the erroneous idea on the presence of both the Lower and Middle Callovian; however, he did not subdivide the latter. In contrast to the opinion of previous researchers (bed “Q” of Karitzky), Nikitin ascribed the sequence of carbonate-free gray clays with violet tint described here in layer 1 of the Monastyrrek-2 and Grigorovka-1 sections (Figs. 6, 9) primarily to the Bathonian. He shows agglutinated euryhaline foraminifera (*Ammodiscus baticus* Dain, etc.) and single belemnite “*Holcobellus blainvillei* (Voltz),” which is considered the Late Aalenian—Early Bathonian (Nikitin, 1969), as well as unspecified ammonite remains. Later, Nikitin (1977) described six forms of belemnites from this level, two of which were first distinguished in the Aalenian of Western Europe. Only after the finding of ammonite in this sequence determined as *Pseudocadoceras mundum* (Sasonov) did Nikitin (1989) ascribe it to the Callovian. It is noteworthy that Nikitin (1969) showed several belemnites which come (according to the revision of Ippolitov) from the upper part of the Koenigi Zone or even from the lower part of the Calloviense Zone. In lithological—stratigraphic columns, however, this part of the section is not shown (Nikitin, 1969, Fig. 2).

Simultaneously with Nikitin, the Kanev Jurassic was studied by A.V. Paryshev (1968a, 1968b, 1969, 1977, etc.), who made a large contribution to the study of

ammonites. He rejected the presence of the Middle Callovian in this region, although, following the predecessors, he erroneously ascribed some Lower Callovian Cardioceratides to “*Quenstedtoceras*.” He subdivided the Lower Callovian into the Macrocephalites macrocephalus and Keplerites gowerianus zones. In the basement of the latter, he included an interval of the section which is distinguished here as the Ch. saratovensis (G. toricellii) Biohorizon (i.e., the upper parts of the Subpatruus Zone). The collection of Paryshev is well reflected in his unpublished dissertation (1969). Judging from the lack of ammonites from the levels above the Gowerianum Subzone in its recent understanding, this researcher, as well as his predecessors, did not study the upper part of the Lower Callovian section. This part of the section is also absent in lithological—stratigraphic columns of sections.

From the Lower Callovian, Paryshev described several new ammonite species; however, some of them are not valid at present. Paryshev, 1968a: “*Quenstedticeras tsytovitchae* sp. nov.” (holotype: this work, Plate 9, fig. 7) = *Pseudocadoceras boreale* Buckman, 1919; Paryshev, 1977: “*Chamoussetia multicostata*, sp. nov.” (holotype: this work, Plate 3, fig. 1; paratype: this work, Plate 3, fig. 2) = *Macrocephalites multicostatus* (Paryshev); “*Chamoussetia recticostata*, sp. nov.” = ?*Ch. saratovensis* Callomon et Wright; “*Quenstedtoceras planus*, sp. nov.” (holotype: this work, Plate 8, fig. 6) = *Pseudocadoceras planum* (Paryshev); “*Q. furcatus*, sp. nov.” = ?“*Ps.*” cf./aff. *mundum* (Sasonov) [?nomen dubium]; “*Keplerites (Sigaloceras) auriculatus*, sp. nov.” = *Toricellites approximatus* Buckman, 1922. It should be noted that the typical *Chamoussetia recticostata* requires revision, because it is highly likely that this species can be a high subjective synonym of *Ch. saratovensis*.

After the construction of the Kanev Reservoir in the valley of the Dnieper River in 1975, many classical coastal outcrops were flooded. This stopped research works for some time. From the 1980s, much attention in the study of the Jurassic rocks of Kanev dislocations was paid to micropaleontology (Pyatkova, 1985, etc.), especially, recently (Klimenko and Dorotnyak, 2009; Matlai, 2009; Shevchuk, 2012). Following an ingrained delusion, the micropaleontologists distinguish the Middle and even Upper substages in the Kanev Callovian.

In last decade, the study of the marine Kanev Jurassic (Callovian) began at a new level. The presence only of the Lower Callovian is shown by ammonites, and the upper part is characterized for the first time: it includes the Curtilobus and Galilaeii subzones of the Koenigi Zone and the entire Calloviense Zone (two-thirds of the biostratigraphic volume of the entire Callovian section and approximately half of its thickness). The zonal scale is adjusted in accordance with the present-day scales of Western Europe and European

Russia. The ammonite infrazonal scale of biohorizons has been elaborated and the elaboration of related infrazonal belemnite scale has started. The nomenclature of the Kanev ammonites and partly belemnites has been adapted in accordance with present-day concepts. The detailed micropaleontological studies consistent with infrazonal ammonite scale has begun.

DESCRIPTION OF SECTIONS

As was noted above, the exposed Jurassic rocks in the area of Kanev dislocations include the Bathonian coastal marine (lagoonal) sedimentary rocks and the Lower Callovian normal marine rocks. The Bathonian deposits are observed in outcrops of the middle part of the Kostyanets Ravine and in cliffs at the right coast of the Kanev Reservoir in the area of the village of Trakhtemirov—the area of Monastyrek, and the village of Grigorovka—the village of Buchak. They are ubiquitously dislocated and include a thick monotonous sequence of ash gray fine-layered clays with a film of small silty material along the layering, thin interlayers of gray clayey dense silt, and lenticular interlayers and horizons of brownish gray solid siderite marl nodules with brown surface. The marls contain fish scale and macrophyte remains.

No primary (nonglacial and nonlandslide) contact between the Bathonian and Lower Callovian was observed. In the northern part of Kanev dislocations, according to Paryshev (1969) and Nikitin (1969), this contact was registered 4.0–4.5 m below the top of the bed, which is described here in the Monastyrek-2 and Grigorovka-1 sections as the number 1 (see below). In the area of Kanev dislocation block, Paryshev (1969) indicated the Bathonian rocks below a 10-m sequence of the Lower Callovian clays with *Paracadoceras elatmae* (Nikitin) in the upper reaches of the Kostyanets Ravine.

The Lower Callovian rocks in the southern and northern parts (Kanev and Buchak–Trakhtemirov blocks, respectively) of Kanev dislocations have a different structure. The Lower Callovian is studied in detail in the sections of the Melanchin and Kostyanets ravines within the Kanev Block and in a series of outcrops in cliffs of the right coast of the Kanev Reservoir in areas of the village Trakhtemirov—area of Monastyrek, and the village of Lukovitsa—village of Grigorovka within the Buchak–Trakhtemirov Block (Fig. 1). The detailed description of most informative sections is given below. The vertical abundance of ammonites in local sections and their biostratigraphic division are shown in the corresponding figures (Figs. 4, 6, 9, 12).

The most complete section of the Lower Callovian rocks of the Kanev block of dislocation is studied in a series of outcrops in the middle part of the **Melanchin Ravine** (Fig. 4). The primary rocks are strongly complicated by folds and injective structures. The beds occur with a dip of 60° and mostly a NW to latitudinal strike.

The lowermost part of the Callovian is exposed in Outcrop IV (Bed 0). There is a small outcrop of brownish gray, unevenly clayey, vaguely layered silt with mica, brown spots, ferruginous lenses, and lenticular platy interlayers of dark gray silty clay. No macrofauna remains were found. The visible thickness is 2.5 m.

Above, the following rocks occur with interruptions in observations (Fig. 4):

1. Brownish dark gray poorly calcareous vaguely layered silty–clayey (transitional) rock with mica, small gypsum crystals and aggregates, and fine interlayers and lenses of light silt. The entire sequence unevenly contains *Bivalvia* shells, compressed ammonite shells, and belemnite rostra. The visible thickness is 14–15 m. The highest thickness of the bed is observed in steeply dipping Outcrop I. In the lowermost part of the layer, D.N. Kiselev previously identified *Macrocephalites cf. verus* (Buckman) and *M. cf. terebratus* (Phillips) (Kiselev and Ippolitov, 2011, bed 1 in figure) in addition to ammonites indicated in Fig. 4.

2a. Grayish brown small- to medium-grained poorly clayey vaguely layered silt with finely-sandy material. The boundary with the underlying bed is clear, uneven, without significant erosion. There are deformed cores of bivalves and ammonites and eroded belemnite rostra. The thickness is 0.20–0.25 m.

2b. Dark gray silty clay with variegated powders of lemon yellow and brown clay to strongly clayey silt. The boundary with the underlying bed is unclear. There are poorly determined remains of bivalves and ammonites and eroded belemnite rostra. The thickness is 0.40–0.45 m.

2c. Reddish brown and greenish dark brown unevenly clayey ferruginous silt. The boundary with the underlying bed is unclear and uneven. There are poorly determined remains of bivalves and ammonites and eroded belemnite rostra. The thickness is 0.15–0.20 m.

In Outcrops II, V, and VI, Bed 2 is strongly ferruginous and lithified up to a soft sandy–clayey siltstone with unrecognized interlayers a, b, and c. It is possible that this layer corresponds to a member of brown sandstones with ammonites of the *Elatmae*, *Subpatruus*, and *Koenigi* zones (revised by Gulyaev), which was described by Paryshev (1969) in the upper parts of the Callovian section of the middle part of the Kostyanets Ravine.

3. Weakly brownish gray to dark gray unevenly silty clay with variegated lemon yellow and brownish red films along numerous discordant fractures. At 0.8, 1.6, and 1.9 m above the base, there are lenticular interlayers (up to 0.1 m) of gray brown (ferruginous on the surface) siliceous–calcareous–clayey strong siltstone. The boundary with the underlying bed is uneven to pocketlike. The poorly determined remains of bivalves and ammonites and eroded belemnite rostra occur close to the bottom. The thickness is up to 2.40 m.

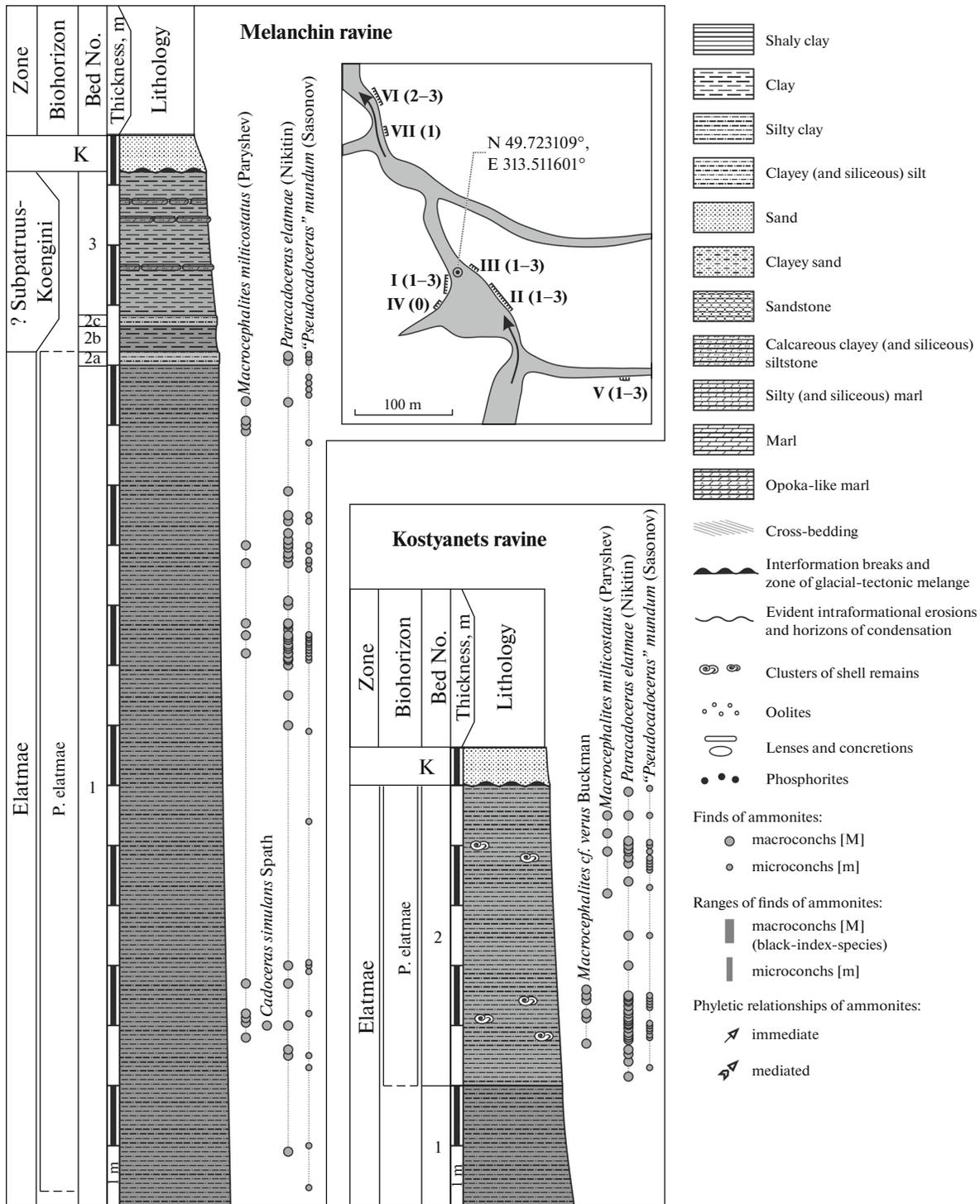


Fig. 4. The Lower Callovian sections of the Melanchin and Kostyanets ravines. The inset, the schematic of location of the Lower Callovian outcrops in the Melanchin Ravine; arrows, the main ravine course; Latin numbers, numbers of outcrops; in brackets, numbers of exposing beds (see text). Here and in text, all coordinates are given after Google Earth®.

The maximum thickness of the layer is observed in Outcrop VI, whereas it does not exceed 0.3–0.4 m in other places. The layer is overlapped with erosion by the Cenomanian light often mélanged sands, the basement of which hosts a condensation horizon up

to 0.1 m thick with typical pearlike phosphorite cores of *Pholas* burrows.

The lower part of this section partly duplicates and, probably, supplements an outcrop which was studied at the right bank of the right tributary of the middle part

of the **Kostyanets Ravine** (49.7425° N, 31.4126° E). The south wing of a sublatitudinal anticline fold hosts the following rocks with increasing dip angles (Fig. 4):

1. Dark gray and brownish gray poorly micaceous silty–clayey (transitional) rock with variegated reddish and lemon yellow spots and films and numerous small gypsum crystals. No macrofauna remains were found. The visible thickness is up to 2 m. This bed, probably, corresponds to Bed 0 in the section of the Melanchin Ravine. Previously, D.N. Kiselev determined *Paracadoceras elatmae* (Nikitin) here (Kiselev and Ippolitov, 2011, bed 4 in Fig. 4).

2. A dislocated member of dark gray brownish gray and grayish beige moderately micaceous poorly calcareous silty–clayey rocks with small gypsum crystals. The boundary with the underlying bed is not sharp, without erosion features. The entire sequence unevenly contains deformed shells of bivalves and ammonites and belemnite rostra. In the upper and lower parts of the bed, the shell remains occur as small nest-like clusters. The approximate thickness is 4–5 m. This bed, probably, corresponds to the lower (not fully exposed) part of Bed 1 in the section of the Melanchin Ravine. The Cenomanian light sands occur above, probably, along the glacial tectonic contact.

In the middle part of the Kostyanets Ravine, Paryshev (1969) described a more complete section of the Lower Callovian. According to his data, its upper part contains a mentioned member of brown sandstones up to 1.3 m thick with an ammonite complex of the Elatmae Zone in the lowermost part and ammonite complexes of the boundary interval of the Subpatruus and Koenigi zones (according to our nomenclature) in the middle and upper parts.

A rich ammonite collection (especially, various *Macrocephalites*) from the Elatmae Zone was sampled in the area of the Kostyanets Ravine in the middle of the 19th century by K.M. Feofilaktov (the collection is stored at the NMNH NAS). Most samples, judging from the matrix, come from strongly ferruginous brown sandy–clayey siltstones full of shell remains. The position of these rocks in the section remains unclear; however, the composition of the ammonite complex allows us to ascribe them to the *P. elatmae* Biohorizon.

The section of the lower part of the Lower Callovian of the northern end of the Buchak–Trakhtemirov block of dislocation was studied in a series of coastal outcrops between the village of Trakhtemirov and the area of Monastyrek. The Callovian rocks are exposed perpendicular to the sublongitudinal strike in several thrust slices. The layers occur with an eastern dip at angles of 40°–60°, on average. The structure of the Callovian rocks in each slice is ordinary. The most complete Callovian section was studied in the easternmost thrust of this area (in the area of **Monastyrek**,

49.9919° N, 31.3870° E). The following rocks occur in a coastal cliff with a dip of 60°–65° (Figs. 5, 6):

1. Gray moderately and poorly silty calcareous-free vaguely layered clay with a poor violet tint, red and lemon yellow films along the fractures and bioturbations, and numerous aggregates of gypsum crystals. There are rare deformed cores of bivalves and ammonites and eroded belemnite rostra. The visible thickness is 2 m.

As was mentioned, the total thickness of this layer, which directly overlaps the Bathonian rocks, is estimated at 4.0–4.5 m by Paryshev (1969) and Nikitin (1969), who conducted the studies before the construction of the Kanev Reservoir. It probably corresponds to Bed 1 in the section of the Kostyanets Ravine.

2. Dark gray strongly clayey (up to silty clay in the lower part) calcareous-free silt with a poor violet tint, red and lemon yellow films along the fractures and bioturbations, numerous aggregates of gypsum crystals, and small pebble of dark gray clay in the upper part. The boundary with the underlying clay is unclear. No macrofauna is found. The thickness is 0.7–0.8 m.

3a. Brownish and reddish gray clayey silt with small pebble of dark gray clay. The boundary with the underlying clay is uneven with features of small erosion. No macrofauna is found. The thickness is 0.5 m.

3b. Brownish gray and grayish brown unevenly clayey poorly calcareous silt with brownish red ferruginous spots, small gypsum crystals, dark gray clayey inclusions, and nest-like clusters of shell detritus. The boundary with underlying bed is unclear. The thickness is 1.5 m.

The entire Bed 3b and all beds up the section contain variously deformed (often poorly identified) shells and cores of bivalves, ammonites, rare gastropods, belemnite rostra, and the remains of other groups of marine invertebrates. This layer probably corresponds to Bed 2 in the section of the Kostyanets Ravine.

4. Greenish and brownish dark gray clayey oolitic (especially, in the lower part) poorly calcareous loose silt. The boundary with underlying bed is uneven, with erosion features, but is lithologically unclear. The thickness is 0.30–0.35 m.

5. Brownish gray strongly clayey silt with greenish tint and gypsum crystals. The boundary with underlying bed is uneven, with erosion features. The thickness is 0.2 m.

6. Grayish yellow siliceous–calcareous–clayey massive moderately strong siltstone with reddish tint. The thickness is 0.2 m.

7. Brownish gray (yellowish brown with grayish tint in the upper part) clayey (especially, in the lower part) silt with gypsum crystals. The thickness is 0.90–0.95 m.

8. Siltstone similar to that described in Bed 6. The thickness is 0.28 m.



Fig. 5. The Lower Callovian Monastyrek-2 outcrop in the Monastyrek area. Here and in Figs. 7, 8, 10, and 11, for numbers of beds, see text.

9. Silt similar to that described in Bed 7. The thickness is 1.7 m.

10. Siltstone similar to that described in Bed 6. The thickness is 0.17–0.20 m.

11. Silt similar to that described in Bed 7. The thickness is 0.60–0.65 m.

12. Siltstone similar to that described in Bed 6. The thickness is 0.20–0.25 m.

13. Grayish red poorly clayey silt. The thickness is 0.25 m.

14. Siltstone similar to that described in Bed 6. The thickness is 0.17–0.19 m.

15. Silt similar to that described in Bed 13. The thickness is 0.22 m.

16. Siltstone similar to that described in Bed 6. The thickness is 0.35 m.

17. Silt similar to that described in Bed 13 with an injective (sill) interlayer of greenish Paleogene sand 5–10 mm thick. The thickness is 0.10 m.

18. Siltstone similar to that described in Bed 6 with lenticular interlayers of silt similar to that described in Bed 13. The thickness is 0.25 m.

The greenish Paleogene sands occur above along the glacial tectonic contact.

Similar structure (with a lower amount of beds in the lower and upper parts) is typical of the Lower Callovian outcrops in coastal cliffs to the northeast of the village of **Trakhtemirov** (49.98° N, 31.36° E).

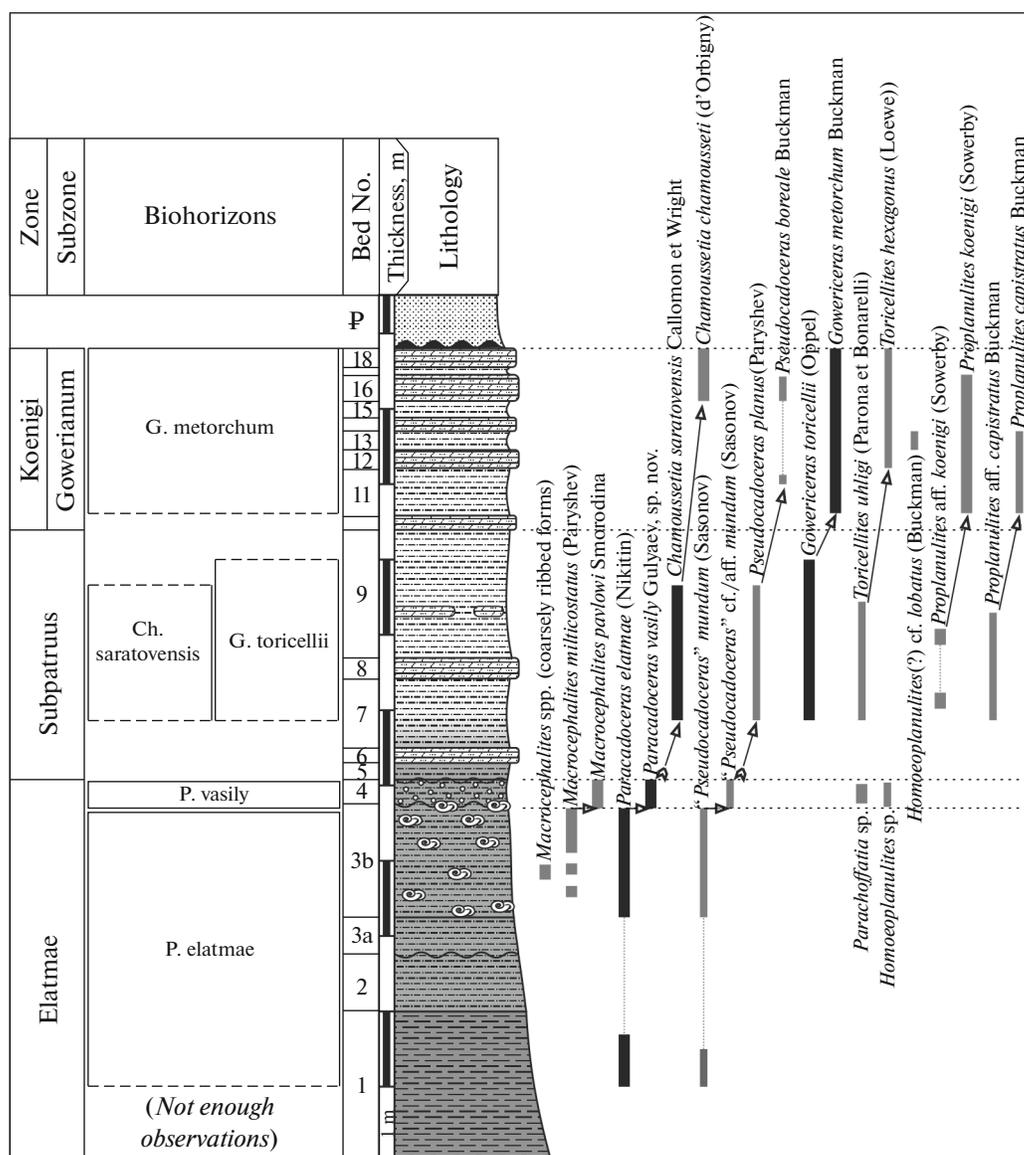


Fig. 6. The Lower Callovian Monastyrek-2 section in the Monastyrek area.

The most complete and less studied Lower Callovian composite section of the Buchak–Trakhtemirov block of dislocation is observed in a series of coastal cliffs between the villages of Grigorovka and Lukovitsa. Here the Callovian rocks are mostly exposed diagonally and parallel to the northwestern strike of the beds in three thrust slices. Two southern slices are located northeast of the village of Grigorovka (Grigorovka-1, -4 and Grigorovka-2, -3) and the northern slice occurs southeast of the village of Lukovitsa (Lukovitsa-1, -2). The sections are complicated by mélangé zones, folds, and faults. The dip directions of the beds vary from the southwest to northwest and the angles range from flat to steep. The slices are divided along the glacial tectonic contacts by sandy Paleogene rocks, whereas these rocks occur on them along the

mélange zone. The Jurassic outcrops in this area stratigraphically duplicate and supplement each other, generally forming a complete section of the Lower Callovian. Separate outcrops are confidently compared by lithological and biostratigraphic features.

The lower part of the Callovian rocks are best exposed in the **Grigorovka-1** section (49.9351° N, 31.4175° E). The following rocks occur in a coastal cliff in two blocks divided by a small reverse fault with a flat dip to the southwest (Figs. 7, 9):

1. Gray silty calcareous-free, locally, vaguely layered clay with weak violet-brown tint, red and lemon yellow films along the fractures, and gypsum crystals. There are deformed cores of bivalves and ammonites and eroded belemnite rostra. The visible thickness is 1 m.



Fig. 7. The Lower Callovian Grigorovka-1 outcrop. In the upper part, the numbers of Beds 1–16 are shown according to the Grigorovka-3 outcrop/section (Figs. 8, 9). Here and in Figs. 8, 10, and 11, the dotted line shows the fault.

2. Brownish gray clayey calcareous-free nonlayered and vaguely layered silt with reddish ferruginous films and small pebble of gray clay near the top. The boundary with the underlying bed is unclear. The composition and preservation of fossils are similar to Bed 1. The thickness is 0.7 m.

3. A member of reddish gray and greenish gray unevenly layer-by-layer clayey calcareous and poorly calcareous silts with red ferruginous spots. Small gray clay pebble was found in an interval of 0.2–0.6 m below the top. The entire bed contains nest-like clusters of shell detritus, the larger of which are abundant in the upper part. The boundary with the underlying bed is uneven, with features of small erosion. The thickness is 2 m.

The entire bed and all beds up the section (as well as the sections described below) contain variously deformed (locally, poorly identified) shells and cores of bivalves, ammonites, rare gastropods, belemnite rostra, and the remains of other groups of invertebrates.

4. Brownish gray clayey oolitic (especially, in the lower part) poorly calcareous loose silt with greenish tint. The middle part of the bed has a hiatus, which is marked by a horizon of rounded belemnite rostra, which are overgrown by serpulides, and *Lopha* shells. Above and below this horizon, the shells of infauna

bivalves typically occur in situ. The boundary with the underlying bed varies from uneven to pocketlike with features of erosion and condensation and lenticular clusters of shell remains, including large ammonites. The thickness is 0.35 m. The beds described correspond to Beds 1–4 in the Monastyrsk-2 section.

5. Brownish gray, poorly clayey, poorly calcareous loose silt with oolites. In interval of 0.06–0.15 m above the bottom, there is an interlayer of gray-yellow siliceous–calcareous–clayey soft silt, locally, with oolites. The thickness is 0.25 m.

6. Gray strongly clayey silt with brownish ferruginous films. The boundary with the underlying bed is lithologically unclear with features of small condensation (a horizon of aggregates of belemnite rostra and shell detritus). The thickness is 0.4 m.

7a. Grayish red and grayish yellow siliceous–calcareous–clayey massive moderately solid siltstone. The thickness is 0.10–0.15 m.

7b. Brownish gray clayey (darker in the upper part, strongly clayey up to silty clay), poorly calcareous, vaguely layered silt with greenish tint. The thickness is 0.85–0.90 m.

Beds 3–7 are also exposed in a small area in the core of an anticline fold 2.3 km to the north, in the northern part of an elongated coastal outcrop east of

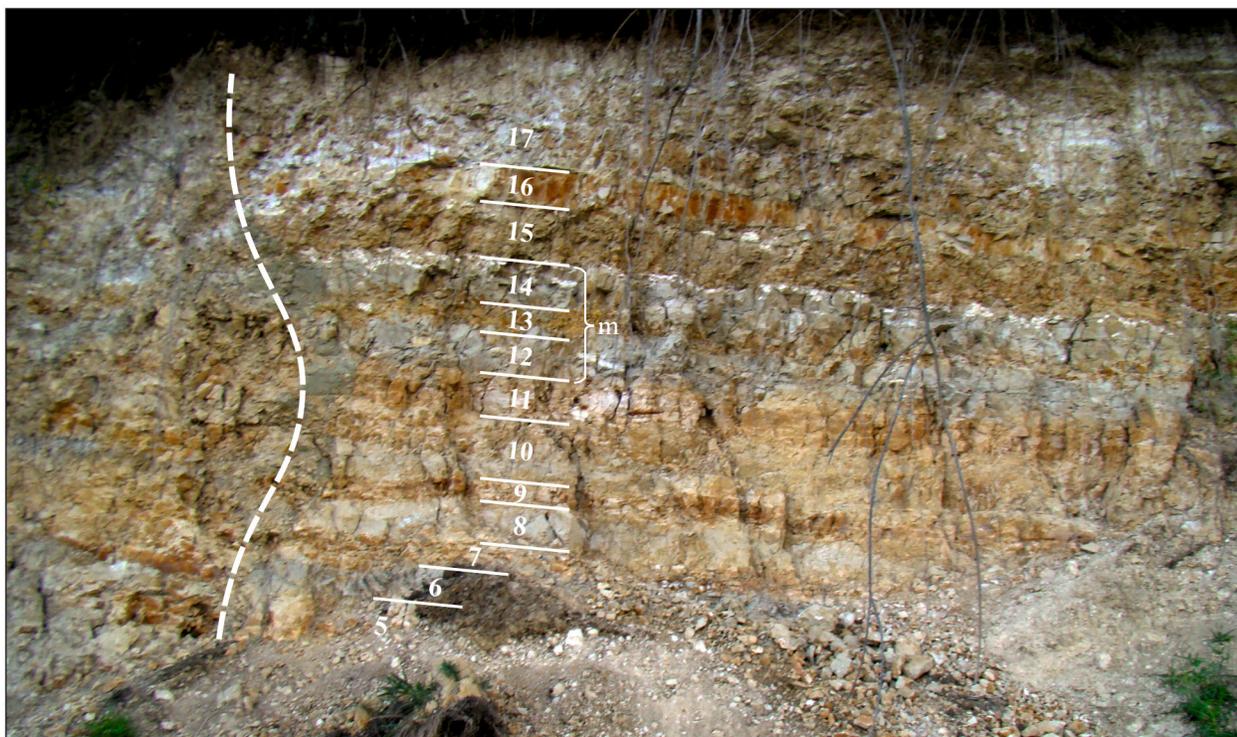


Fig. 8. Fragment of the Lower Callovian Grigorovka-3 outcrop. The numbers of beds are also shown in the upper part of the outcrop from Fig. 7.

the village of Lukovitsa, in the **Lukovitsa-2** section (49.9562° N, 31.4227° E).

8a. Siltstone similar to that described in Bed 7a, which contains gypsum along the contact with the previous bed. The thickness is 0.10–0.15 m.

8b. Grayish red and grayish yellow clayey (darker and clayey in the upper part) silt. The thickness is 0.35–0.40 m.

9a. Siltstone similar to that described in Bed 7a. The thickness is 0.2 m.

9b. Silt similar to that described in Bed 8b. The thickness is 0.8 m.

10a. Siltstone similar to that described in Bed 7a. The thickness is 0.1–0.3 m.

10b. Silt similar to that described in Bed 8b. The thickness is 0.2–0.4 m.

11a. Siltstone similar to that described in Bed 7a. The thickness is 0.2–0.4 m.

11b. Silt similar to that described in Bed 8b. The thickness is 0.2–0.4 m.

12a. Siltstone similar to that described in Bed 7a, but is slightly lighter and less clayey. The thickness is 0.15 m.

12b. Brownish yellow calcareous vaguely layered silt. The thickness is 0.15 m.

12c. Very strongly clayey silt transiting to silty clay to the top. Yellowish gray calcareous finely layered and vaguely layered rock with greenish tint (it has darker color at general background) and numerous micro-shell detritus. The boundary with the underlying bed is unclear. The thickness is 0.4 m.

The above beds are difficult to access for a detailed study in a steep cliff; however, they are well traced 0.5 km to the north, in the **Grigorovka-3** section (49.9395° N, 31.4163° E). A dark clayey layer, which corresponds to the upper part of Bed 12c in the Grigorovka-1 section, is exposed near the water; the following rocks occur directly in the coastal cliff with a small dip to the northwest (Figs. 8, 9):

1. Light brown siliceous–calcareous–clayey massive moderately solid siltstone with grayish tint. The thickness is 0.25–0.30 m.

2. Yellowish gray clayey poorly calcareous vaguely layered silt. The thickness is 0.1 m.

3. Siltstone similar to that described in Bed 1. The thickness is 0.23 m.

4. Yellowish gray strongly clayey poorly calcareous vaguely layered silt, which is darker against the background of other rocks. The thickness is 0.12 m.

5. Reddish yellow siliceous–calcareous–clayey massive soft or moderately solid siltstone with grayish

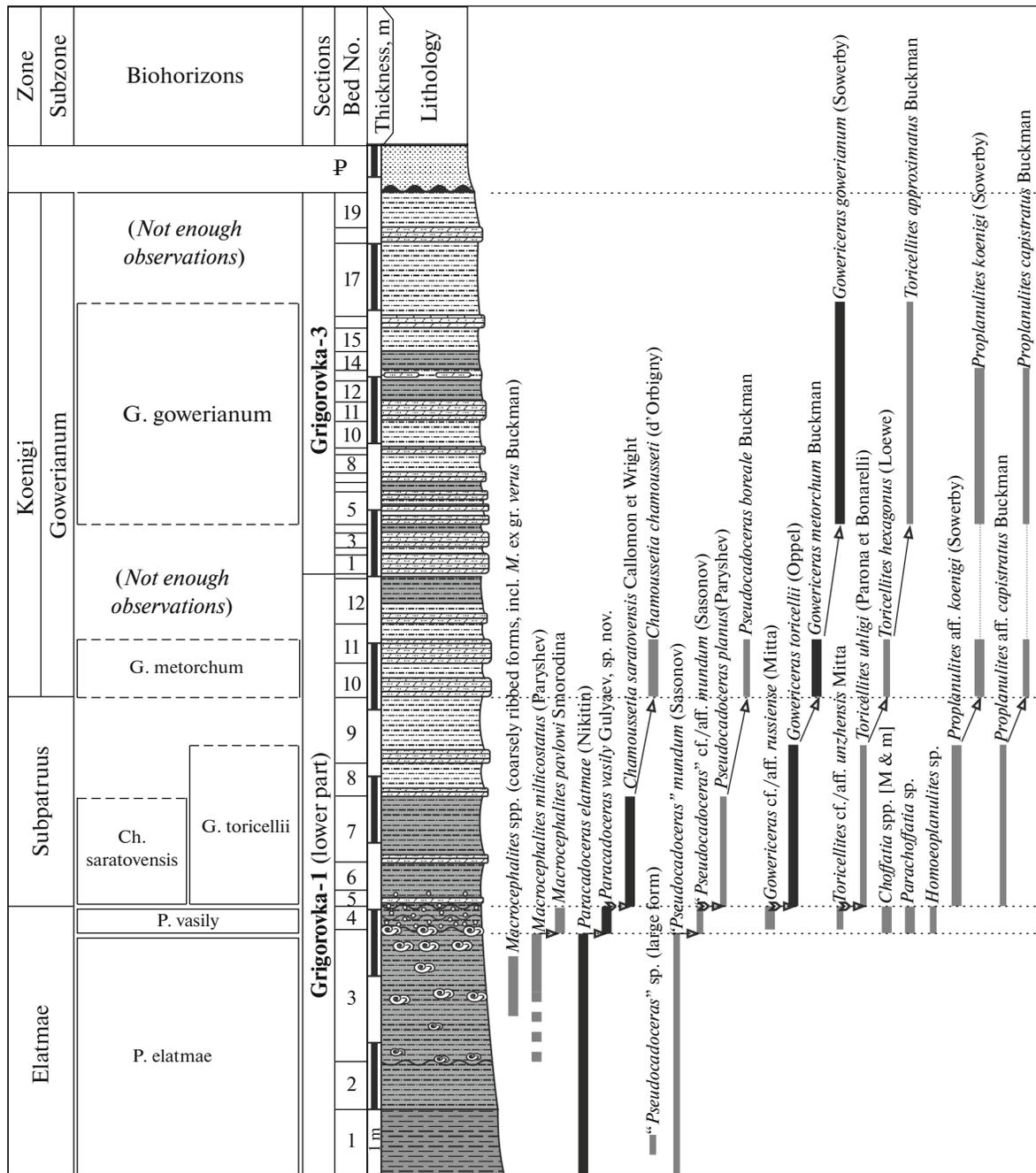


Fig. 9. Section of the lower part of the Lower Callovian in the area of the village of Grigorovka.

tint, bright brownish red color along the fractures, and interlayers of brownish yellow dense silt. The thickness is 0.5 m.

6. Silt similar to that described in Bed 4. The thickness is 0.14 m.

7. Siltstone and silt similar to those described in Bed 5 with a lenticular interlayer of light gray opoka silty marl with violet tint and fine parallel layering. The thickness is 0.14–0.15 m.

8. Yellowish gray clayey poorly calcareous dense silt with reddish tint. The thickness is 0.27 m.

9. Siltstone similar to that described in Bed 5. The thickness is 0.11 m.

10. Silt similar to that described in Bed 8. The thickness is 0.4 m.

11. Siltstone similar to that described in Bed 5, which becomes loose up to silt in the upper part. The thickness is 0.3 m.

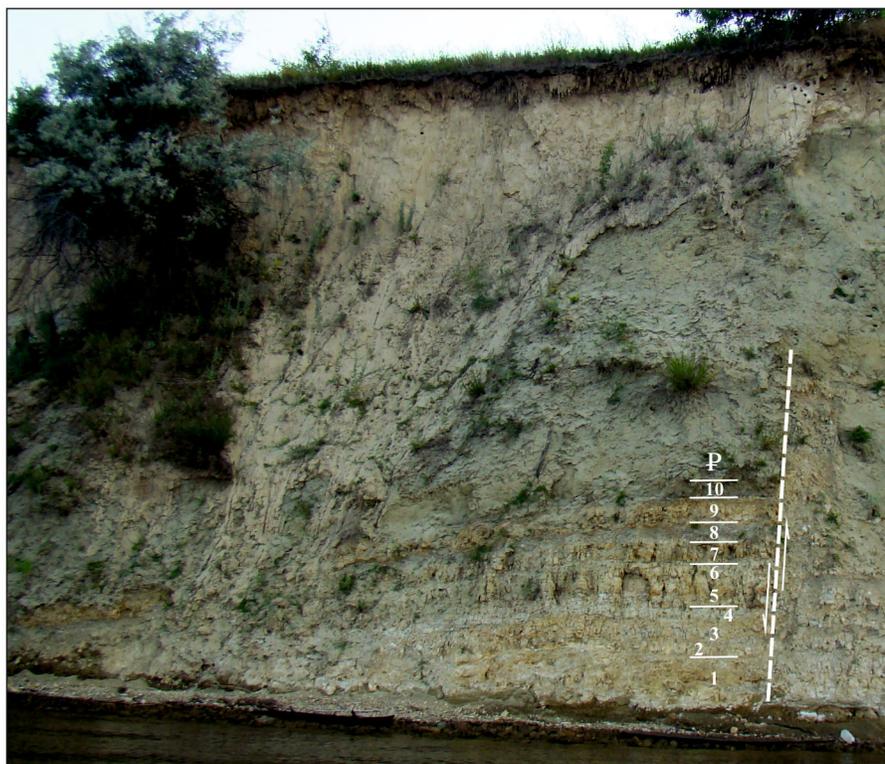


Fig. 10. The Lower Callovian Grigorovka-4 outcrop.

12. Silt similar to that described in Bed 4. The thickness is 0.3 m.

13. Siltstone and silt similar to those described in Bed 5. The thickness is 0.15–0.18 m.

14. Silt similar to that described in Bed 4. The thickness is 0.27 m.

15. Greenish brown clayey poorly calcareous vaguely layered silt with yellowish tint and gypsum. The thickness is 0.35 m.

16. Light gray almost white silty soft marl with yellowish tint (reddish brown along the fractures). The thickness is 0.18–0.20 m.

17. Silt similar to that described in Bed 15. The thickness is 1.1 m.

18. Siltstone similar to that described in Bed 5. The thickness is 0.22 m.

19. Silt similar to that described in Bed 15. The thickness is 0.5 m or more.

The greenish Paleogene sands occur above along the glacial tectonic contact.

The overlying Lower Callovian rocks are exposed in a small **Grigorovka-4** outcrop, which is located directly south of the Grigorovka-1 section and which is divided from it by a series of reverse faults. The following rocks with a gentle dip occur here from the water level (Figs. 10, 12):

1. Grayish red and reddish gray unevenly clayey silt with an interlayer of brownish gray siliceous–calcareous–clayey solid siltstone up to 5 cm thick at 0.7 m below the top, a lenticular interlayer of light gray (almost white with yellowish tint) silty soft marl up to 10 cm thick at 0.4 m below the top, and an interlayer of gray strongly clayey silt 4–5 cm thick directly above. The visible thickness is 0.70–0.75 m.

2. Light gray (almost white with yellowish tint) silty soft marl. The thickness is 0.10–0.15 m.

3. Silt similar to that described in Bed 1. The thickness is 0.3 m.

4. Light gray (with yellowish greenish tint) clayey silt. The thickness is 0.12–0.25 m.

5. Yellowish gray (with greenish tint) and grayish red (reddish brown along the fractures) siliceous–calcareous–clayey moderately solid siltstone. The thickness is 0.35 m.

6. Silt similar to that described in Bed 4 (slightly darker). The thickness is 0.10–0.15 m.

7. Siltstone similar to that described in Bed 5. The thickness is 0.21–0.25 m.

8. Light gray unevenly silty clay with brownish tint. The thickness is 0.25 m.

9. Reddish brown siliceous–silty solid brecciated marl. The thickness is 0.10–0.15 m.

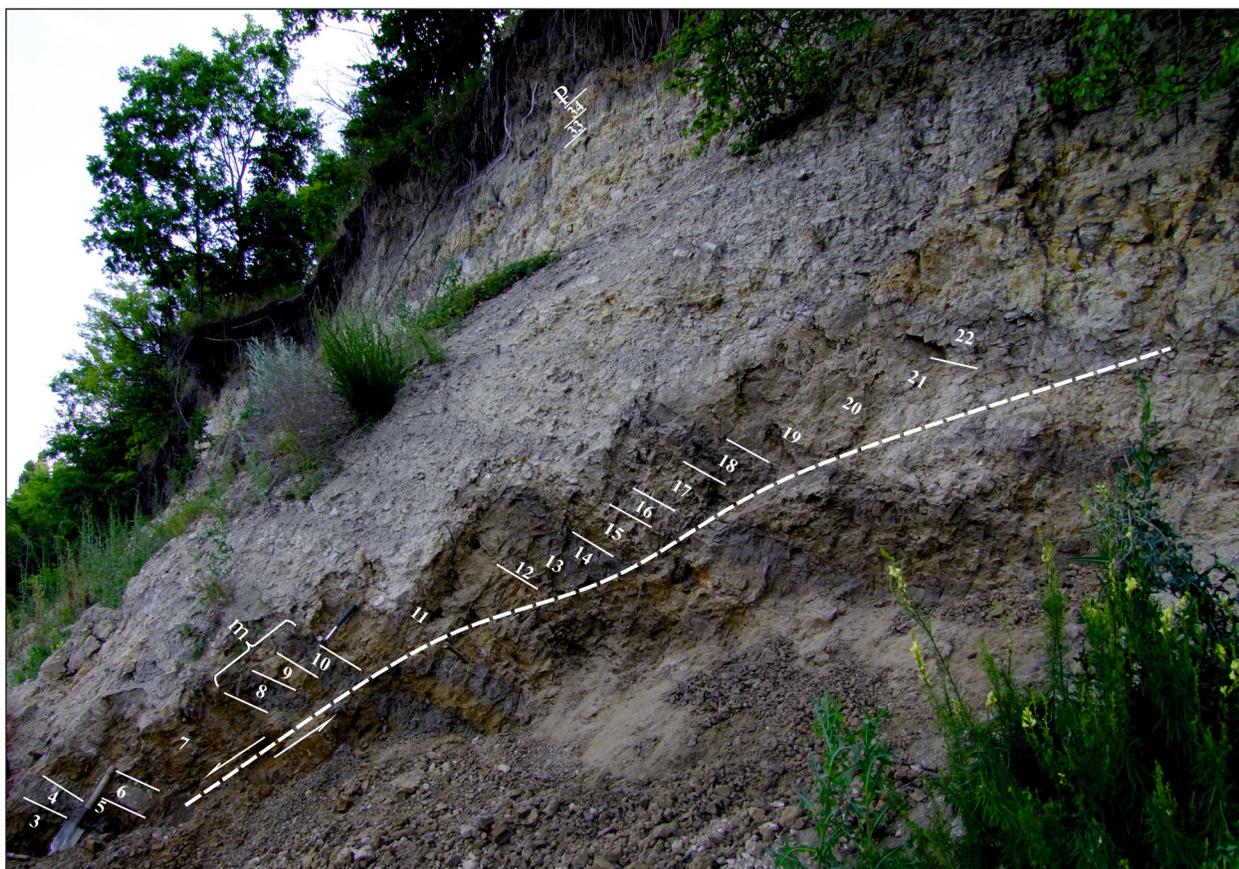


Fig. 11. The Lower Callovian Lukovitsa-1 outcrop.

10. Grayish red silty (to clayey silt) strongly weathered clay. The thickness is 0.10–0.15 m.

The greenish Paleogene sands above occur along the glacial tectonic contact.

The beds corresponding to the upper half of the Grigorovka-1 section, the Grigorovka-3 section, and the lower part of the Grigorovka-4 section are exposed in the **Grigorovka-2** section, which occurs 0.3 km north of the first one (49.9381° N, 31.4167° E). Here the Callovian rocks are strongly dislocated, partly occur vertically, and are complicated by mélange zones.

The rocks corresponding to the upper part of the Grigorovka-4 section and overlying beds are exposed in the southern part of an elongated coastal outcrop of the **Lukovitsa-1** section (east of the village Lukovitsa) (49.9548° N, 31.4226° E). Here the blocks of grayish yellow siliceous–calcareous–clayey solid and moderately solid siltstone with deformed cores of *Gowericeras indigestum* (Buckman) and *Proplanulites ferruginosus* Buckman are washed out from under the water level. The following rocks with a western dip occur from the water level (Figs. 11, 12):

0. Gray silty clay. The visible thickness is 0.2 m.

1. Brownish gray and grayish brown siliceous–silty vaguely layered solid marl. The thickness is 0.15 m.

2. Gray silty nonlayered clay with whitish microcrystalline gypsum along the fractures, small aggregates of gypsum crystals, and brownish oxidation spots. The thickness is 0.25–0.30 m.

Beds 0–2 described correspond to Beds 8–10 in the Grigorovka-4 section, but are less weathered.

3. Marl similar to that described in Bed 1, which transits to reddish brown clayey silt in the upper 5 cm of the layer. The thickness is 0.22–0.25 m.

4. Clay similar to that described in Bed 2. The thickness is 0.22 m.

5. Dark red clayey silt with whitish aggregates of small crystalline gypsum along the fractures and a lenticular marl interlayer similar to that described in Bed 1. The thickness is 0.08–0.10 m.

6. Brownish gray unevenly silty nonlayered clay with a horizon of flatten nodules (up to 20 × 10 cm) of light gray almost white soft marl in the upper part. The thickness is 0.22 m.

7. Marl similar to that described in Bed 1 with a weak violet tint and a grayish brown and brownish gray

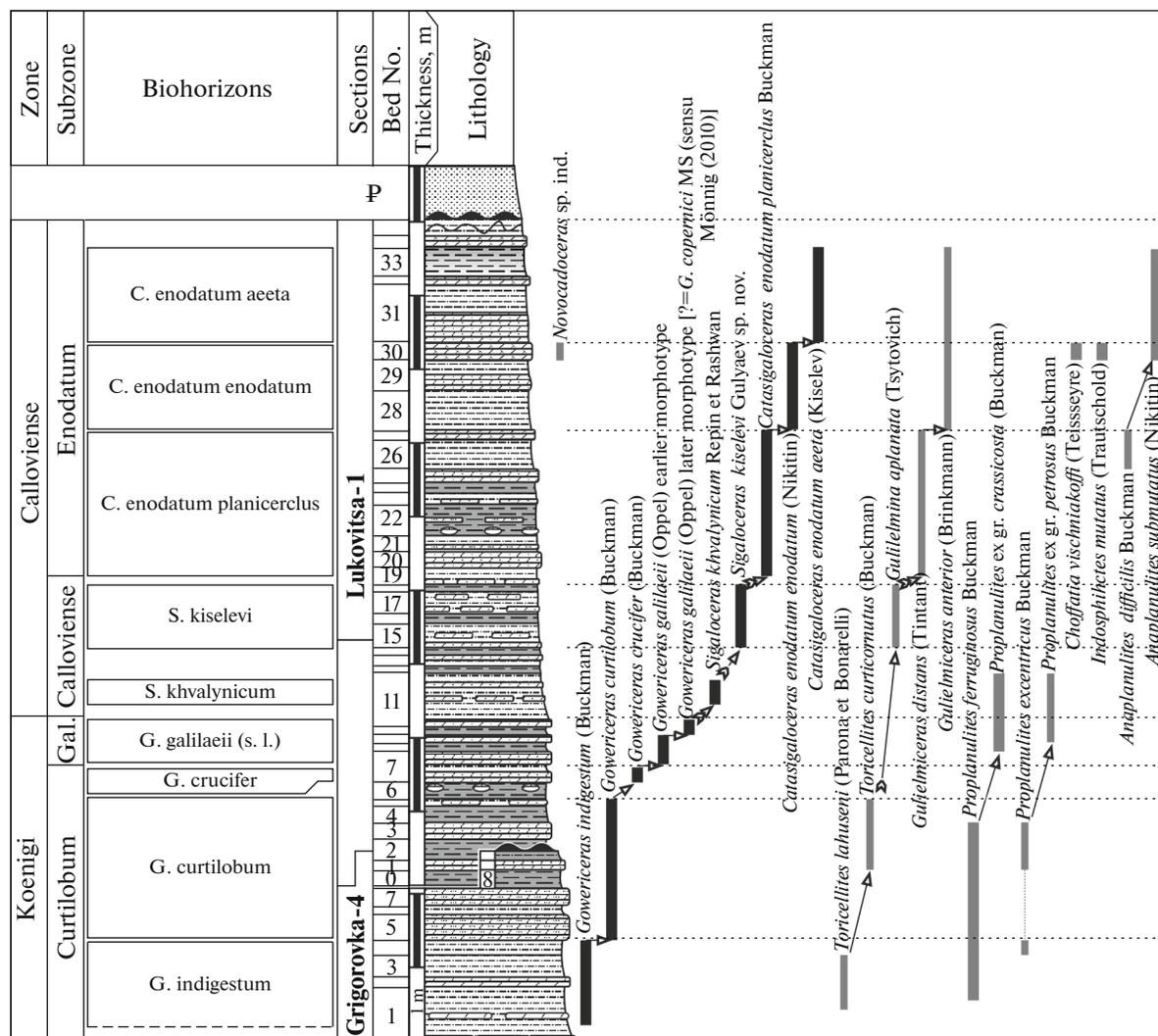


Fig. 12. Section of the upper part of the Lower Callovian in the area of the villages of Grigorovka and Lukovitsa. Gal., Galilaei.

clayey silt 5–10 cm thick in the middle part of the bed. The thickness is 0.40–0.45 m.

8. Gray silty vaguely layered clay with lenses of reddish clayey silt in the lower part, brown elongated inclusions (bioturbations?), and whitish aggregates of microcrystalline gypsum along the fractures. The thickness is 0.10–0.15 m.

9. Grayish yellow (locally, reddish) siliceous–silty moderately strong and soft marl, which transits to the top to silt of the same color with interlayers of gray clay. The thickness is 0.1 m.

10. Gray silty clay with whitish aggregates of microcrystalline gypsum along the fractures. The thickness is 0.10–0.13 m.

11. Grayish yellow (locally, reddish) clayey vaguely layered silt with interlayers of gray silty clay and interlayers of grayish yellow and grayish brown (locally, with violet tint) siliceous–silty moderately strong marl

up to 10 cm thick at the bottom, 0.35 and 0.15 m below the top. The thickness is 0.70–0.75 m.

12. Clay similar to that described in Bed 10. The thickness is 0.1 m.

13. Silt similar to that described in Bed 11 with an interlayer of the same marl 5–8 m thick close to the top. The thickness is 0.15 m.

14. Clay similar to that described in Bed 10. The thickness is 0.1 m.

15. Silt similar to that described in Bed 11 with interlayers of the same marl 4–8 m thick in the basement and the middle part of the bed. The thickness is 0.32–0.34 m.

16. Clay similar to that described in Bed 10. The thickness is 0.1 m.

17. Silt similar to that described in Bed 11 with interlayers of flattened nodules of the same marl close to the bottom and the top. The thickness is 0.3 m.

18. Clay similar to that described in Bed 10. The thickness is 0.1 m.

19. Silt similar to that described in Bed 11 with a lenticular interlayer of the same marl up to 5 cm thick in the basement. The thickness is 0.22 m.

20. Grayish brown and brownish gray strong siliceous-silty marl. The thickness is 0.22 m.

21. Silt similar to that described in Bed 11 with an interlayer of the same marl up to 5 cm thick 0.07 m from the bottom. The thickness is 0.22 m.

22. Gray unevenly silty clay with weak brownish and greenish tint, a horizon of flattened nodules (up to 20 × 10 cm) similar to that described in Bed 6 near the bottom, and a lenticular interlayer of marl up to 5 cm thick similar to that described in Bed 11. The thickness is 0.40–0.45 m.

23. Silt similar to that described in Bed 11 but more clayey with a lenticular interlayer of the same marl up to 5 cm thick. The thickness is 0.15 m.

24. Clay similar to that described in Bed 22. The thickness is 0.15 m.

25. Gray and grayish brown (reddish brown along the fractures) siliceous-silty strong marl. The thickness is 0.18 m.

26. Yellowish light gray strongly clayey vaguely layered silt transiting to silty clay up the section. The thickness is 0.4 m.

27. Opoka-like poorly silty strong marl, locally, with gray (occasionally, with violet tint) and red (up to brownish red) spots. The thickness is 0.13–0.14 m.

28. Silt transiting to clay similar to that described in Bed 26. The thickness is 0.53–0.55 m.

29. Yellowish light gray and grayish yellow (with greenish tint and brightly red along the fractures) siliceous-silty, mostly, soft marl transiting to clayey silt up the section to yellowish gray silty clay at the top. The thickness is 0.4 m.

30. Opoka-like marl similar to that described in Bed 27. The thickness is 0.23–0.26 m.

31. Layer lithologically similar to that described in Bed 29. The thickness is 0.75–0.80 m.

32. Opoka-like marl similar to that described in Bed 27. The thickness is 0.10–0.14 m.

33. Light gray (with greenish yellowish tint) strongly silty clay transiting to darker less silty clay up the section. The thickness is 0.4 m.

34. Gray (bright red to red-brown) opoka-like marl strong, brecciated. The thickness is 0.1–0.2 m.

35. Callovian mélanged weathered siliceous-calcareous-silty rocks. The thickness is 0.1–0.5 m.

The Paleogene dark green sandy-silty rocks above occur along the glacial tectonic contact containing a flattened silica pebble with rounded-conchoidal surface in the basement.

Thus, the Grigorovka-1, -3, and -4 and Lukovitsa-1 sections successively and variously overlap and complement each other (Figs. 9, 12). No direct overlapping is observed only between the Grigorovka-3 and -4 sections; however, the first one is completely characterized by *Gowericeras gowerianus*, whereas the second one is characterized by *G. indigestus* in the lower part. These species are directly phylogenetically related indices of two successive biohorizons, which allows us to exclude any significant break in the observations between these sections.

For comparison, we present original (composed by Gulyaev) schemes of the most complete sections of the Lower Callovian of the Lower (Saratov) and Upper (Kostroma) Volga region (Figs. 13, 14), which were previously published in little-known editions. The authors often appeal to a scheme of one Bathonian–Callovian section of the Central (Nizhny Novgorod) Volga region composed by Gulyaev (Rogov et al., 2012, Fig. 3).

INFRAZONAL METHOD IN BIOSTRATIGRAPHY

The Lower Callovian sections of Kanev dislocations allow us to trace in detail the sequence of ammonite complexes and evolution lines (lineages, phylines, phylems) of their guide representatives. This makes it possible to use both zonal and infrazonal (biohorizons) units for the stratigraphic division and correlation of rocks.

Over the last four decades, the infrazonal approach has come into wide practice in ammonite stratigraphy of the Jurassic system. The use of infrazonal units—biohorizons (faunal horizons) allowed the researchers to significantly increase the detailed division and accuracy of correlation of marine sedimentary rocks, thus proportionally increasing the resolution of the study of many events in Earth's evolution. In addition, the biohorizons are much more convenient to use than the zonal units, which bear a load of historical succession. This is especially topical for the Jurassic system, in which, from the period of Albert Oppel, many ammonite zones in fact became quasi subsubstages, which require further biostratigraphic detailing.

The works of J.H. Callomon (1984a, 1985, etc.), who defined the term “faunal horizon” and substantiated the principles of identification and use of these strata, initiated a rapid development of the present-day ammonite infrazonal stratigraphy. Many elements of infrazonal methods were established in the end of the 19th century in works of V. Waagen, M. Neumar, and S. Buckman (Rogov et al., 2012). The contribution of Buckman is the most important in this respect. He introduced the term “hemera,” which is now considered as the geochronological equivalent of the biohorizon, and widely used it in stratigraphic targets

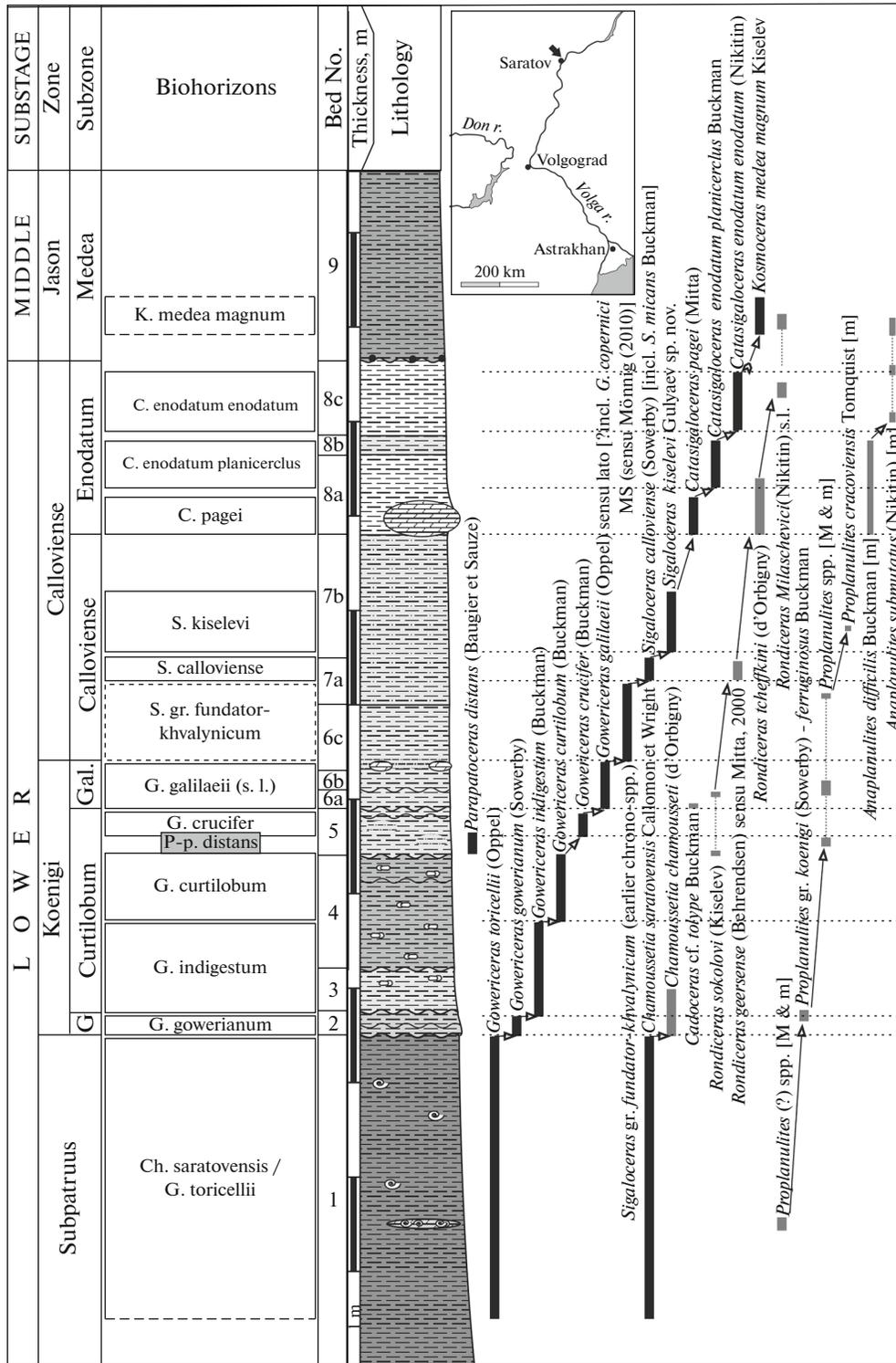


Fig. 13. The Callovian TETs-5 section in the northern outskirts of the city of Saratov, updated after (Gulyaev and Ippolitov, 2013, Fig. 5). No ranges of findings of microconch species (except for those indicated as [m]) are shown. G., Gowerianum; Gal., Galilaei. Inset, the position of the section (indicated by arrow).

(Buckman, 1887–1907, 1893, 1902, 1909–1930). A series of specific works dedicated to the nature, determination, nomenclature, history, and principles of identification and use of infrazonal units was pub-

lished from the periods of fundamental works of Callo- mon (Page, 1995; Gulyaev, 2002a, 2015d; Gulyaev and Rogov, 2016; Gulyaev et al., 2010; Rogov et al., 2012; Zakharov et al., 2007; etc.).

From the position of current experience of infra-zonal stratigraphy, a biohorizon should be considered as a biostraton with a unique guide index taxon of a species group (species/subspecies), which cannot be stratigraphically (thus, geochronologically) subdivided on a taxonomic basis. We can say that the *biohorizons are the volumetric areas of their index species in geographical and stratigraphic (as well as in equivalent chronological) space*. Such volumetric biohorizon areas are considered as undivided elemental biostratons (virtual biostratigraphic bodies). In geographical–stratigraphic space, they form “vertical chains” in the case where they are established by successive species of one phyloline or can be overlapped (interpenetrate) in a varying degree if they are based by species not directly related phylogenetically. The potential degree of detail of a three-dimensional system of biohorizons directly depends on internal taxonomic differentiation of a guide group, which is related to the rate of its evolution and the degree of study.

We can generally state that there is some *fundamental volume* of the biohorizon which is limited by a dynamic paleoarea of distribution of the index species during its existence. In practice, however, the biohorizon in a certain section corresponds to the observed interval of abundance of the index species; in turn, only the index species can substantiate the identification of a certain biohorizon. Thus, in an individual section or a regional group of sections, there is only an *realized volume* of the biohorizon, which is limited by primary local paleoecological (unsuitable environmental conditions, etc.) and secondary local geological (hiatuses, barren intervals, etc.) factors.

Having both lower and upper boundaries in any sections, the biohorizon in principle differs from conventional units of a stratigraphic hierarchy, which are identified by the lower boundary in a stratotype. In its nature, it does not belong to this hierarchy. The biohorizons are recognized on the basis of an objective community of a single biostratigraphic feature (the presence of the index species), whereas the conventional straton are divided on the basis of a subjective difference in a complex of stratigraphic features. From the methodological viewpoint, both (lower and upper) boundaries of the biohorizon are principal limits of accuracy of measurement of a selected biostratigraphic method (as minimum divisions of measuring scale irrespective of its scale) and should be considered presumptively isochronous in remote sections in spite of potential diachrony.

If we abstract from the mentioned local geological and paleoecological factors, the first and last occurrence of guide species in a certain regional/local section is related to migration (immigration, invasion) and evolutionary (phyletic transition, divergence, extinction) events. The recognition of successive biohorizons within one region (paleobasin, paleobiochorem) expediently the use of index species belong-

ing to one evolution line. This excludes possible stratigraphic overlapping of these *phylogenetic biohorizons* and minimizes the potential diastems between them, wherein their stratigraphic range tends to fundamental. As a rule, the representatives of the most massive geographically wide abundant and fast evolving phyloline are selected; however, these properties often contradict each other. Thus, in a complex regional scale, it is often convenient to use several parallel successions of biohorizons based on index species of different phylolines. In addition, the regional section can exhibit stratigraphically local invasions of the representatives of a guide group from another region. They, as a rule, are good markers for wide interregional correlations and can be the basis for intercalation of *immigration biohorizons*. It should be remembered, however, that the local (realized) stratigraphic range of such biohorizons can be significantly narrower than the stratigraphic range of their index species in a region of the primary area. Intermediate in nature and properties between these two types of biogorizons are biogorizons based on index species that have migrated to the region and continued their evolution there. In this case, the lower and upper boundaries of the biohorizon will be migratory and phylogenetic, respectively. The same properties (in reverse order) will be typical of the boundaries of the biohorizons based on phyloline-terminated species, for which we cannot exclude the presence of the relict areas.

A rapid development of the infrazonal method against the background of its primarily weak theoretical substantiation led to inevitable anarchy in approaches of recognition and nomenclature of biohorizons. In order to unify them, Gulyev et al. proposed a project of basic nomenclature rules of recognition and description of biohorizons (Gulyaev, 2002a; Gulyaev et al., 2010; Rogov et al., 2012), which are briefly summarized below. The main nomenclature characteristics include availability and validity.

The **availability** of the biohorizon name consists of several criteria. (1) The *name* should consist of a word “biohorizon” (or its synonym) and the available name of the index taxon of the species group. The descriptions and revisions also indicate the Latinized name of the author and the year of publishing of the biohorizon. (2) The new name of the biohorizon should be *published* following the same criteria which are accepted in current International codes of zoological and botanical nomenclature. (3) The *index species/subspecies* of the biohorizon should have a available (not necessary valid) name. (4) The biohorizon should have a *stratotype* which preserves the nomenclature name and provides for its potential falsifiability.

The **validity** of the biohorizon is determined by a triple priority principle which includes subordinate principles of (1) minuteness, (2) continuity, and (3) seniority (priority). (1) According to the *minute-*

ness principle, the biohorizon having a lower equivalent geochronological range has priority over the biohorizon having a larger equivalent geochronological range. (2) According to the *continuity* principle, the biohorizon recognized by a species/subspecies of the same phyletic line as the adjacent one has priority over the biohorizon recognized by a species/subspecies of another phyletic line if it is in agreement with principle 1. (3) According to the *seniority* principle, the oldest available name of the biohorizon has priority over the younger one if it is in agreement with principles 1 and 2.

The nomenclature of the biohorizons is related to the nomenclature of index species. (1) If the name of the index species objectively changes (with retention of nomenclature type), the name of the biohorizon also automatically changes, and if its author is considered the same, his surname (the author) is put in brackets. (2) If the name of the index species is recognized as invalid because of subjective synonymy, the name of the biohorizon also becomes invalid. The author of the new name of the biohorizon will be the author who revised it for the first time.

PHYLOGENY AND BIOGEOGRAPHY OF AMMONITES

As was emphasized above, the leading role in elaboration and comparison of infrazonal biostratigraphic scales is played by phylogenetic successions and migrations of the representatives of the guide group, in this case, ammonites. Thus, one of the first tasks of studies is the recognition of these successions and principles of evolutionary processes in them, as well as the identification of ways, directions, and relative time of migration events.

At the end of the Bathonian, the East European marine basin was broadly connected only to Arctic seas (Gulyaev, 2001a, 2005a, 2005b; Gulyaev and Kiselev, 1999, etc.). Beginning from the Callovian, during a vast ongoing transgression in the Northern Hemisphere, the basin became constantly linked to marginal seas of the periphery of Tethys in the south (in the area of the Cis-Caspian Depression and Caucasus) and epicontinental seas of Western Europe in the west (in the area of the Pripyat Trough) (Gulyaev, 2001a, 2005a, 2005b; Sazonova and Sazonov, 1967; etc.). Owing to active migration of the low-latitude marine biota to the East European basin, it was biogeographically separated at the beginning of the Callovian from the Greenland province of Arctic (Boreal) Realm and became an East European province of the Boreal–Atlantic (Subboreal) Realm (paleobiochoremes revised after (Meledina, 1994)). During the Callovian, the “Boreal degree” of this basin generally decreased (Gulyaev, 2005b), which is especially evident in its southwestern (Dnieper–Donets) part

with the territory of Kanev dislocations. This is explained both by latitudinal (paleoclimate) position of this basin and its direct link through the Pripyat Strait and Poland Sea to basins of Western Europe, which provided a migration of low-latitude ammonite groups and other marine animals, as well as in the opposite (western) direction.

During the Early Callovian, the East European marine basin was generally dominated by Boreal and Subboreal ammonite groups: the high Boreal family Cardioceratidae Siemiradzki, low Boreal family Kosmocerotidae Haug, and Subboreal subfamily Proplanulitinae Buckman (family Perisphinctidae Steinmann). Cardioceratids include independently evolved subfamilies Chamousetiinae² Alekseev et Repin [=“Paracardoceratinae MS” (Gulyaev, 2014)] and Cadoceratinae Hyatt. Chamousetiinae became extinct in the Boreal–Atlantic Realm and the western sector of Arctic at the beginning of the Koenigi phase, whereas the relatively slowly evolved Cadoceratins yield further diversity of Cardioceratids (Gulyaev, 2005a, 2009, 2014). Kosmocerotids include subfamilies Gowericeratinae Buckman (=Keppleritinae Tintant) and Kosmocerotinae phyletically changing each other in the middle of the Calloviense phase. The taxonomic boundary between them should follow the moment of termination of rapid evolutionary phetalization (paedomorphosis) of adult shell during the transition from *Sigaloceras* Hyatt to *Catasigaloceras* Buckman (Fig. 19), the representatives of which are characterized by many features of the earlier species of the subgenus *Kosmoceras* (*Gulielmites*) Buckman (Kiselev, 2001). The Proplanulitins, which include only genus *Proplanulites* Teisseyre, appear during the Subpatruus phase (=the end of the Herveyi phase) and their origin is probably connected with the subfamily Grossouvriinae³ Spath.

² The scarcely used subfamily Chamousetiinae was primarily recognized on the basis of ontogenetic features of a suture line of the representatives of the genus *Chamousetia* R. Douville (Alekseev and Repin, 1989). The evolution of the Middle Jurassic cardioceratids allows us to ascribe the phylogenetically related genera *Paracardoceras* Crickmay (sensu lato, incl. subgen. *Catacardoceras* Bodylevsky), *Stenocardoceras* Imlay, and *Cadoceramousetia* Mitta to this subfamily. The evolution paths of the predecessors of Chamousetiinae and jointly evolved Cadoceratinae diverged, probably, at the end of the Bajocian, when inflated spherococone *Greencephalites* Repin deviated from discocone *Arctocephalites* Spath (probably, yet from *Cranocephalites* Spath) (Fig. 16) (Gulyaev, 2009, 2011, 2014; Mitta, 2016; Mitta and Alsen, 2013; Repin et al., 2007; etc.). In the newest taxonomic review (Howarth, 2017), *Greencephalites* is included in a synonymic of the subgenus *Catacardoceras*; however, our phylogenetic reconstruction of the Bajocian–Callovian cardioceratids contradicts this conclusion.

³ Until recently, the representatives of this group were typically considered in the structure of Pseudoperisphinctinae Schindewolf according to (Arkell, 1950; *Treatise...*, 1957). In the newest taxonomic review (Enay and Howarth, 2019), a poorly characterized typical genus *Pseudoperisphinctes* Schindewolf is ascribed to synonymic *Wagnericeras* Buckman in the structure of the subfamily Zigzagiceratinae Buckman.

The last representatives of *Proplanulites* became extinct in the middle of the Calloviense phase, probably, leaving no descendants (Gulyaev, 2001b; Kiselev, 2001).

In some stages of the Early Callovian, the Tethyan (sensu lato) groups played a noticeable role in the ammonite complexes of the East European basin. For example, the representatives of the family Macrocephalitidae Salfeld were widespread, although they were relatively few in number in the Elatmae phase and at the very beginning of the Subpatruus phase. The ammonites of the subfamily Grossouvriinae, which were few in number at the end of the Elatmae phase and, probably, Subpatruus phase and were not recognized later, became significant in the Enodatum sub-phase after the extinction of Proplanulitins. In addition, the short-time invasions of other low-latitude ammonites occurred periodically. These ammonites include either few findings such as *Oxycerites czapskii* Mitta (Oppeliidae H. Douville family) (Mitta, 2004a) or a extensive narrow stratigraphically consistent migration level with *Parapatoceras* spp. (subfamily Parapatoceratinae Buckman, (?) family Spiroceratidae Hyatt) (Gulyaev, 2002b; Gulyaev et al., 2015; Mitta and Seltser, 2006).

Using the infrazonal method, many recent studies considered a detailed species reconstruction of phylogeny of various ammonite groups of the Early Callovian of the East European marine basin and adjacent basins (Gulyaev, 1999, 2001a, 2001b, 2005a, 2009, 2015a, 2015d; Gulyaev and Rogov, 2009; Kiselev, 2001, 2005, 2013; Kiselev and Rogov, 2007; Mitta, 1999, 2000, 2008b, 2011; etc.). The most important reconstructed phyletic successions are shown in Fig. 15.

In a detailed subdivision of the lower part of the Lower Callovian (Elatmae and Subpatruus zones) of the East European paleobiogeographic province, the leading role belongs to a phyloline of the subfamily **Chamoussetiinae**, which links a provincial branch *Paracadoceras* (Subgen. nov. 1) → *Cadochamoussetia* Mitta → *Chamoussetia* R. Douville. It regionally continues the evolution of archaic pan-Boreal subgenus *Paracadoceras* (*Catacadoceras*) Bodylevsky (Fig. 16), the representatives of which (identified by the presence of coarse ribs on the adult body chamber) migrated to the East European marine basin from Arctic in the Late Bathonian (Gulyaev, 2001a, 2009; Gulyaev and Kiselev, 1999; Mitta, 2005). At the very beginning of the Callovian during the transgression in the Northern Hemisphere, *Paracadoceras* is subdivided into three primarily geographically differentiated phyletic branches (Gulyaev, 2009, 2011, 2012, 2014). The evolution of the East European branch of *Paracadoceras* and its descendant followed neendemism. Precisely the East European province is endemic for these ammonites in the terminology of (Callomon, 1985) and they propagated to the adjacent basin from this marine area.

In the Early Callovian, Chamoussetiinae of the East European basin form a well traced phyloline: *P. poultoni* Gulyaev [Gulyaev, 2005a, p. 65: nom. nov. pro *C. bodylevsky* Frebald sensu Poulton (1987, holotype: pl. 27, figs. 4–6)] → *P. primaevum* (Sasonov) [= *C. frearsi* (d'Orb.) sensu Nikitin (1885, Tab. X(XII), fig. 52)] → *P. chvadukasyense* nom. provis. [see "*P. sp. nov.* (aff. *elatmae*)" in (Gulyaev, 2009, Fig. 2)] → *P. elatmae* (Nikitin) → *P. vasily* sp. nov. → *C. tschernyschewi* (Sokolov) → *C. surensis* (Nikitin) sensu lato⁴ → *C. subpatruus* (Nikitin) → *C. uzhovkensis* Gulyaev [Gulyaev, 2005a, p. 66: nom. nov. pro *Ch. saratovensis* sensu Mitta (1999) et Gulyaev (2001a, holotype: pl. IV, Fig. 3)] → *Ch. saratovensis*⁵ Callomon et Wright → *Ch. chamousseti* (d'Orbigny) sensu lato (Figs. 15, 17). This phyloline exhibits rather rapid change in the form of the shell from cadicone⁶ (*Paracadoceras*) through discocone (*Cadochamoussetia*) to oxycone (*Chamoussetia*). During the evolution, the inner whorls become more involute with progressively increasing differentiation (furcate coefficient) of ribs. In successive species of *Paracadoceras*, initially there is a gradual expansion of the umbilical funnel by reducing the steepness of its walls. *P. elatmae* has the most open umbilicus. During the next stage, beginning from *P. vasily* sp. nov., the umbilical walls of adult whorls become steeper up to vertical (*Cadochamoussetia* and *Chamoussetia*), resulting in a fast narrowing of umbilicus during the evolution. Synchronously, beginning from the latter mentioned species, on the adult shell the number of the umbilical bullae progressively decreases, they become shorter and more individualized ("squeezed") and completely vanish beginning from *C. subpatruus*. In addition, the reviewed phyloline up to *C. tschernyschewi* is characterized by a progressive reduction of secondary ribs, which are smoothed in ontogenesis on the ventral side of the earlier whorls. Beginning from *C. surensis*, however, the ventral parts of the ribs become stronger, propagating to later ontogenetic stages with more angular section of the ventral side. The progressive evolutionary reduction of ribs occurs

⁴ As seen from Fig. 17, *C. surensis* is evidently divided into two chronosubspecies/species; however, their nomenclature division is difficult, because a lectotype (Nikitin, 1885, Tab. X(XII), fig. 54) mentioned in (Mitta and Starodubtseva, 1998, p. 7; Mitta, 1999, p. 128) represents damaged inner whorls, which cannot indicate the belonging to the early or late form (subspecies/species).

⁵ A morphologically similar form *Amm. lamberti crobyloides* is known in the Callovian rocks of Southwest Germany (Quenstedt, 1887, Taf. 90, fig. 19; present work, Plate 8, fig. 1). The single specimen, however, is probably lost (Schlegelmilch, 1985) and its stratigraphic position is discussible, which makes problematic the use of the name "*Ch. crobyloides*," as was mentioned previously (Gulyaev, 2005a; Gulyaev and Ippolitov, 2013; Gulyaev et al., 2002, 2014).

⁶ Hereinafter, the names of the main types of planispiral shells of ammonites (ecomorphs/biomorphs) follow the classical terminology (*Treatise...*, 1957) and "Westermann triangle" (Westermann, 1996).

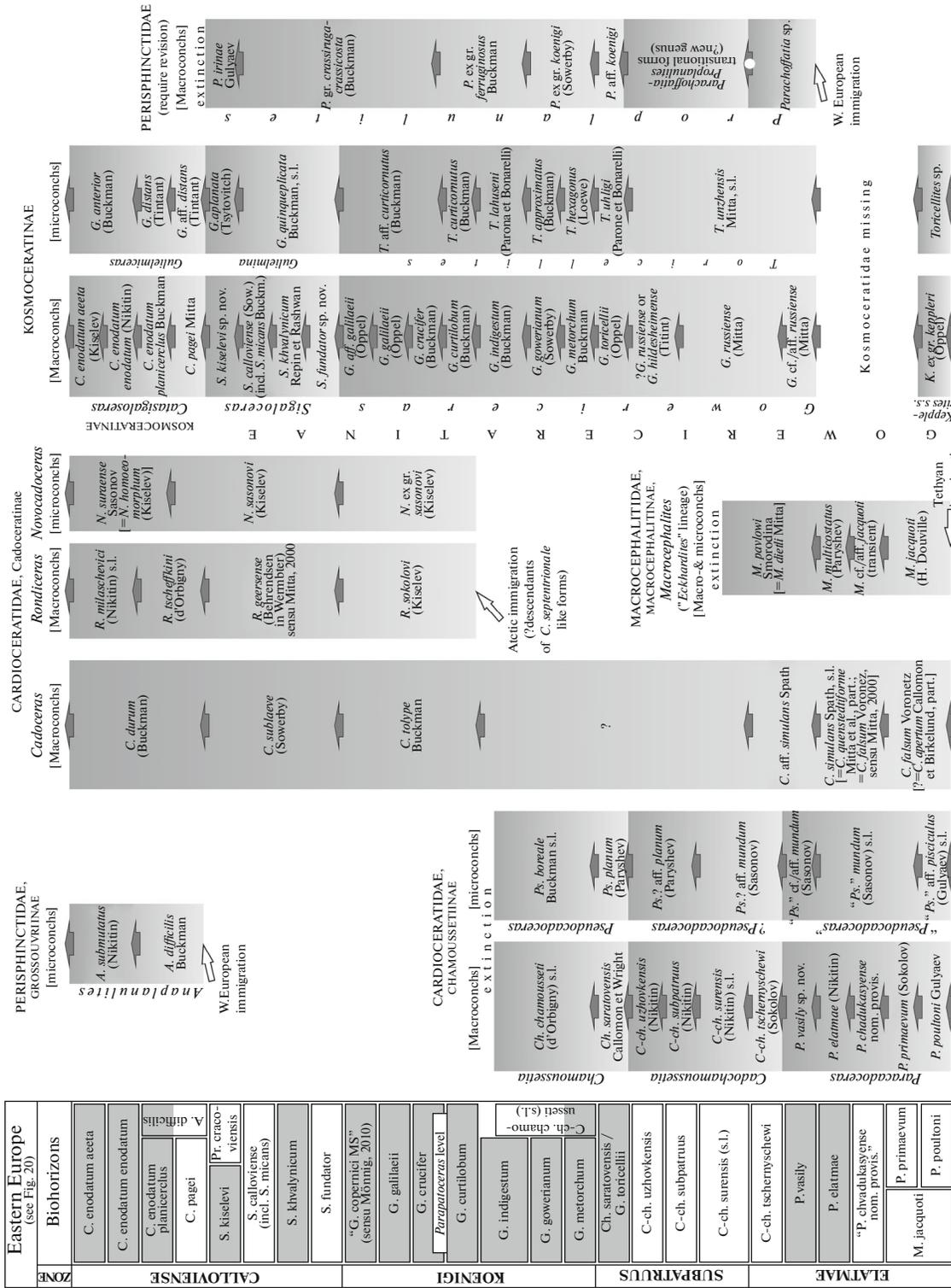


Fig. 15. Evolutionary successions of the representatives of various ammonite groups in the Early Callovian of the East European marine basin (European Russia and Central Ukraine) after (Gulyaev, 1999, 2001a, 2001b, 2005a, 2009, 2015a, 2015d; Gulyaev and Rogov, 2009; Gulyaev and Ippolitov, 2013; Kiselev, 2001, 2005, 2013; Kiselev and Rogov, 2007; Mitta, 1999, 2000, 2008b; Rogov et al., 2012; etc.). In the infrazonal chart: the names of provisory biohorizons indexed by undescribed species are in quotation marks. Gray color marks the biohorizons present in the lower Callovian of Kanev dislocations.

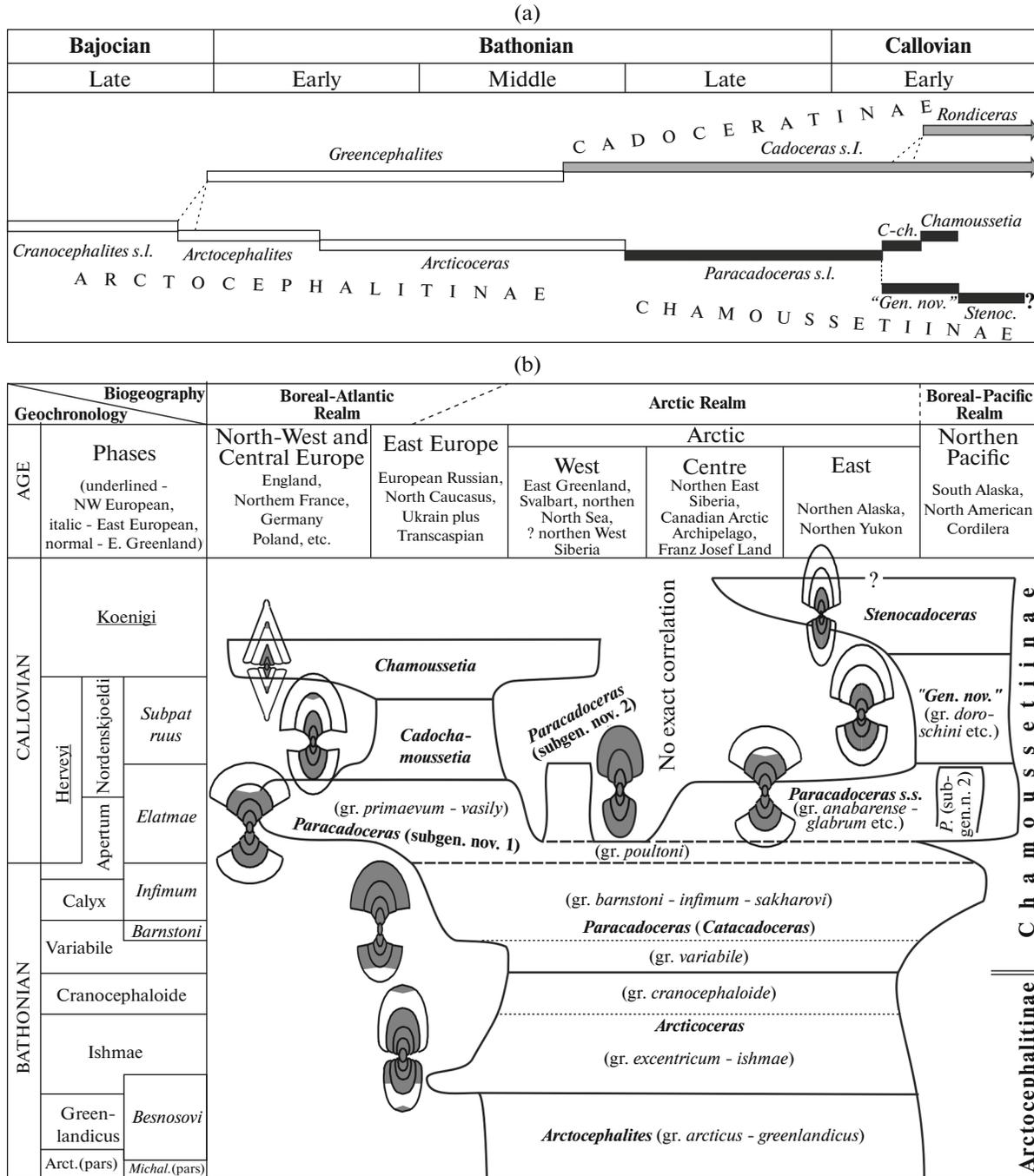


Fig. 16. (a) Phylogenetic links of subfamilies and genera of Cardiocerataidae in the Late Bajocian–Early Callovian; (b) Evolutionary-biogeographic scheme of the subfamily Chamoussetiinae, modified after (Gulyaev, 2009, 2011, 2014). The schematic sections of adult shells decreased by 6–7 times, in which dark color indicates the whorls covered with ribs, are provided at the level of ranges of occurrences of individual taxa of the genus group. Phases/zones are given approximately in a scale of the amount of biohorizons/hemeras in them. The comparison of zonal charts of various regions is given after (Gulyaev, 2013a, 2015d, 2019). *C-ch.*, *Cadochamoussetia*; *Stenoc.*, *Stenocadoceras*; Arct., Arcticus; Michal., Michalskii. Remark: *Paracadoceras* (subgen. nov. 1) is a group which combines the representatives of the *P. poultoni* Gulyaev–*P. primaevum* (Sasonov)–*P. chvadukasyense* nom. provis.–*P. elatmae* (Nikitin)–*P. vasily* sp. nov. phyloline. In the early Callovian, its representatives were dominant and evolved mostly in the East European marine basin. *Paracadoceras* (subgen. nov. 2) is a group with reverse evolving coarse ribbing on the adult body chamber, which combines *P. nordenskjoldi* (Callomon et Birkelund) (Callomon, 1985 (Appendix), 1993) typical of East Greenland and its direct predecessors (not described in nomenclature) (Gulyaev, 2012), as well as South Alaskan *P. catostoma* (Pompeckj) (Imlay, 1953). The evolution of these groups is considered and illustrated in detail in (Gulyaev, 2009, 2011, 2012, 2014).

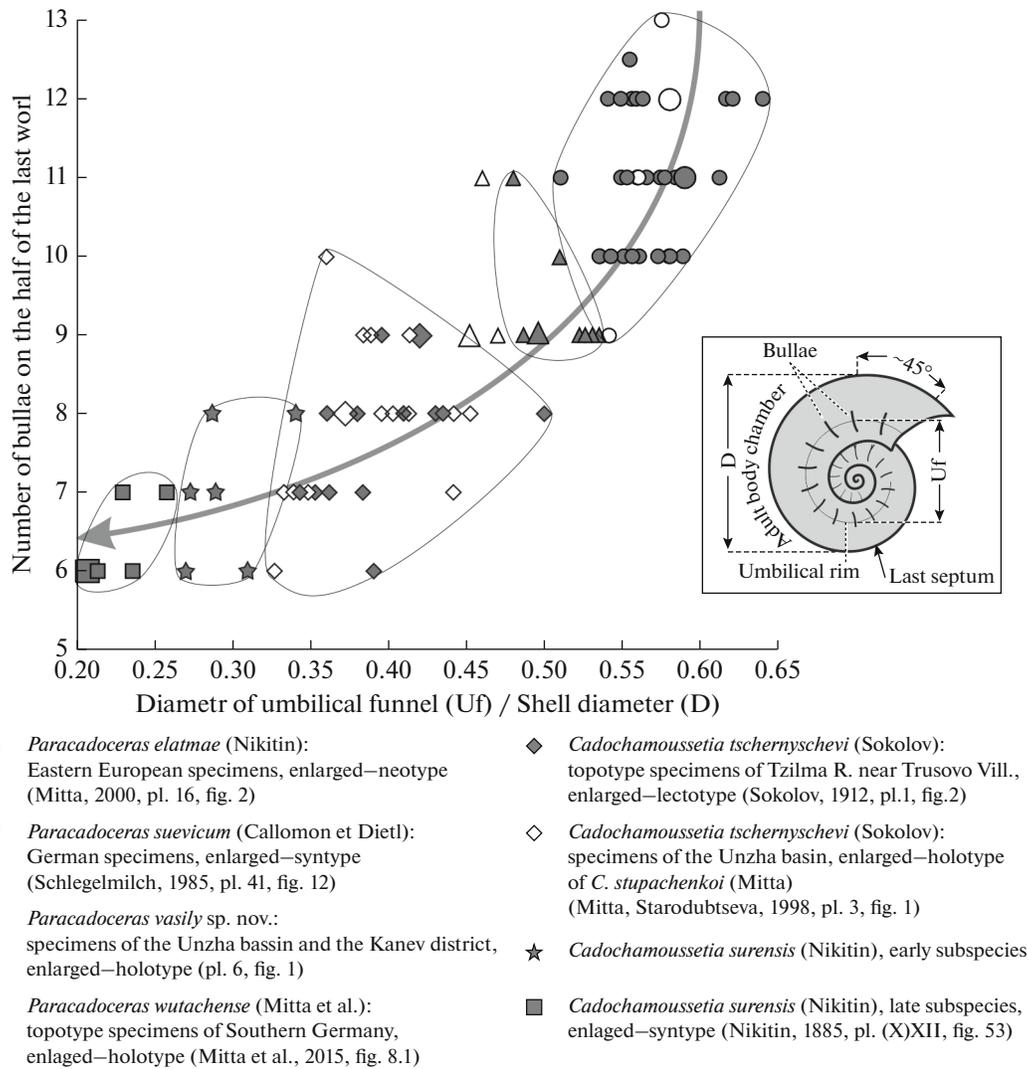


Fig. 17. Change in areas of features (Bezier curves) of adult shell during evolution transition from *Paracadoceras* to *Cadochamousetia*. Here and in Figs. 18 and 19, the inset shows the scheme of measurements.

on the lateral surfaces of the whorls. As seen from the above data and Fig. 17, the evolution trends of various features in this phyloline change (refract) in the range of *P. elatmae*–*C. surensis*. Thus, the division of the genera *Paracadoceras* and *Cadochamousetia* should occur between the *P. vasily* sp. nov. and *C. tschernyschewi*⁷. In the transition from *C. uzhovkensis* to *Ch. saratovensis*, a sharpened keel appears on the adult body chamber - a feature of the genus *Chamousetia*, which becomes squeezed in *Ch. chamouseti* s.l. This most geographi-

⁷ In Fig. 17, *P. wutachense* (Mitta et al., 2015), which was recently defined in the Herveyi Zone of Southwest Germany, morphometrically occupies a position between *P. vasily* sp. nov. and *C. tschernyschewi*. At present, however, it is difficult to say whether it belongs to a common East European phyloline or it is a local geographical derivative of *P. elatmae* (incl. *P. suevicum* (Callomon, Dietl)) that migrated to the Central European basins.

cally widespread species is the last in the phyloline, which becomes suddenly extinct at the beginning of the Koenigi phase, probably, following an inadapive scenario in the terminology of (Rasnitsyn, 1986). Against the background of the adaptive norm loosed by rapid “inadapive” evolutionary changes, *Ch. chamouseti* is characterized by extremely high individual variability in vast local samplings. A series of nominal species of *Chamousetia* is described from the lower part of the Koenigi Zone (*Ch. stuckenbergii* (Lahusen), *Ch. hyperbolica* (Buckman), *Ch. phillipsi* Callomon et Wright, *Ch. buckmani* Callomon et Wright); however, it is difficult to recognize them for sure. A relatively long occurrence of the terminal species in the inadapive phyloline is in agreement with ideas on slowing (up to complete stop) directed (goal-setting) evolution under destabilization of the adaptive norm (Rautian, 1988).

A similar scenario is observed in the inadaptive phylo-line *Macrocephalites* (*Eckhardites*) endemic for the East European basin (Gulyaev, 2015a; see below).

During the evolution, the microconchs of this phylilone, which are ascribed to the genus *Pseudocadoceras* Buckman (sensu latissimo) (Fig. 15), exhibit a gradual increase in differentiation of ribs and more involute shell with acute ventral side (Kiselev, 1996).

In the Lower Callovian of Kanev dislocations, Chamousetiins are strongly dominant in the ammonite complexes of the *P. elatmae* and *P. vasily* biohorizons, composing 80–85%, on average, of their amount. In the *Ch. saratovensis* and *G. metorchum* biohorizons, the quantitative abundance of the representatives of this subfamily approximately corresponds to or is slightly lower than the abundance of other ammonites: *Gowericeratins* and *Proplanulitins*. No Chamousetiins in this region are found above the *G. metorchum* Biohorizon. At the same time, they occur inclusively up to the *G. indigestum* Biohorizon in the Volga region and European north of Russia (Gulyaev, 2001a, 2005a; Gulyaev and Ippolitov, 2013, 2016; Kiselev, 2006; Mitta, 2000), as well as in Western Europe (Callomon et al., 1988, 1989) and East Greenland (Callomon, 1993).

The ammonites of the subfamily **Cadoceratinae**, which in the Lower Callovian included abundant genera *Cadoceras* Fischer and *Rondiceras* Troitzkaya (beginning from the *Curtilobum* Subzone) and corresponding microconchs (Fig. 15) in eastward and northward parts of the East European Platform, occur extremely rarely in the area of Kanev dislocations. We found only single *Cadoceras simulans* Spath in the *P. elatmae* Biohorizon of the Melanchin Ravine section (Fig. 4) and a single small specimen of the *Novocadoceras* sp. ind. microconch in the *C. enodatum enodatum* Biohorizon of the Lukovitsa-1 section (Fig. 12).

For the detailed subdivision of the upper part of the Lower Callovian (Koenigi and Calloviense zones) of the Boreal–Atlantic Realm, a leading role in general is played by a phyliline of the family **Kosmoceratidae**, which relates *Gowericeras*⁸ Buckman → *Sigaloceras* Hyatt → *Catasigaloceras* Buckman. It is evident that *Gowericeras* originates from *Keplerites* s.s. Neumayr et Uhlig, but the evolutionary transition between them has not been reconstructed in detail yet. In Europe, the last representatives of *Keplerites* s.s. of the group *K. kepleri* (Oppel) occur in the lowermost parts of the Callovian and, up the section, Kosmoceratids are completely absent in several biohorizons (Callomon

et al., 1988, 1989; Gulyaev, 2001a, 2005a, 2015d; Kiselev and Rogov, 2007; Mönnig, 2014, 2017; Mönnig and Dietl, 2017).⁹ In East Greenland, *Keplerites* s.s. are abundant up to the lower part of the Nordenskjöldi Zone (*P. nordenskjöldi* α , β biohorizons) (Callomon, 1993). This level is compared with the upper part of the East European *Elatmae* Zone and the middle part of the West European *Herveyi* Zone (Fig. 16) (Gulyaev, 2011, 2012, 2015a, 2015d). In North America, the local representatives of *Keplerites* s.s. also probably existed slightly longer than in Europe and it seems that they have no descendants (Callomon, 1984b). The first rare *Gowericeras* of the group *G. russiense* (Mitta) appear in Central Ukraine and Central Russia in the upper parts of the *Elatmae* Zone, in the *P. vasily* (Plate 5, figs. 2, 3) and *P. tschernyschewi* biohorizons (Gulyaev, 1999, 2001a, 2005a, 2015d; Gulyaev and Ippolitov, 2013; Mitta, 2000; Mitta and Starodubtseva, 1998; this work). In this stratigraphic range, *Gowericeratins* are absent in the Pechora basin: they are recognized only in the lower parts of the Koenigi Zone (Gulyaev, 2007; Gulyaev and Ippolitov, 2016). In East Greenland, these ammonites also appear only in the lower parts of the Koenigi Zone (Callomon, 1993). In Western Europe, the first representatives of *Gowericeras* are known in the upper parts of the *Herveyi* Zone (Mönnig, 2014; Mönnig and Dietl, 2017).

All these circumstances allow suggestion that *Gowericeras* originated in the end of the *Elatmae* phase as a neoendemic derivative of *Keplerites* s.s. in the southwestern and central parts of the East European marine basin and was only widespread in the entire Boreal–Atlantic Realm and adjacent basins by the end of the *Herveyi*/Subpatruus phase—the beginning of the Koenigi phase. The species *K. tenuifasciculatus* Callomon from the eponymous biohorizon of the *Apertum* Zone of East Greenland (Callomon, 1993, 2004), which approximately corresponds to the middle part of the *Elatmae* Zone (Gulyaev, 2011, 2012, 2015a, 2015d), can be a possible predecessor of *Gowericeras*. This specific species has relatively evolute whorls and thin dense ribbing, which make it similar to *G. russiense*. It cannot be excluded that the direct predecessors of *Gowericeras* should be found in the area of the North Caucasus basin, where they could have been pushed aside at the beginning of the Callovian by an

⁸ Typically, *Gowericeras* is considered a subgenus of the genus *Keplerites* Neumayr et Uhlig (s.l.); however, phylogenetically, the successive species of the former represents an individual specific stage in evolution of Kosmoceratids (Figs. 15, 18). This gives grounds to increase the rank of *Gowericeras* to genus as was primarily considered by Buckman (1921, p. 54; see also Howarth, 2017).

⁹ The representatives of *Keplerites* s.s. indicated in (Mitta, 2000, 2004b, 2008a; Mitta and Starodubtseva, 2000) from the lower parts of the *Elatmae* Zone of the Central Volga region, in fact, originate from the Upper Bathonian Infimum Zone (Gulyaev, 2005a, 2013a, 2015d; Kiselev and Rogov, 2007; Mönnig and Dietl, 2017). At present, poorly preserved remains of Kosmoceratids in the complex with *Macrocephalites jacquoti* (Douville) are reliably known only in the section near the settlement of Prosek (Nizhny Novgorod oblast) in the lower parts of the *Elatmae* Zone of the Volga region (Gulyaev, 2001a, 2005a, 2015d; Kiselev and Rogov, 2007).

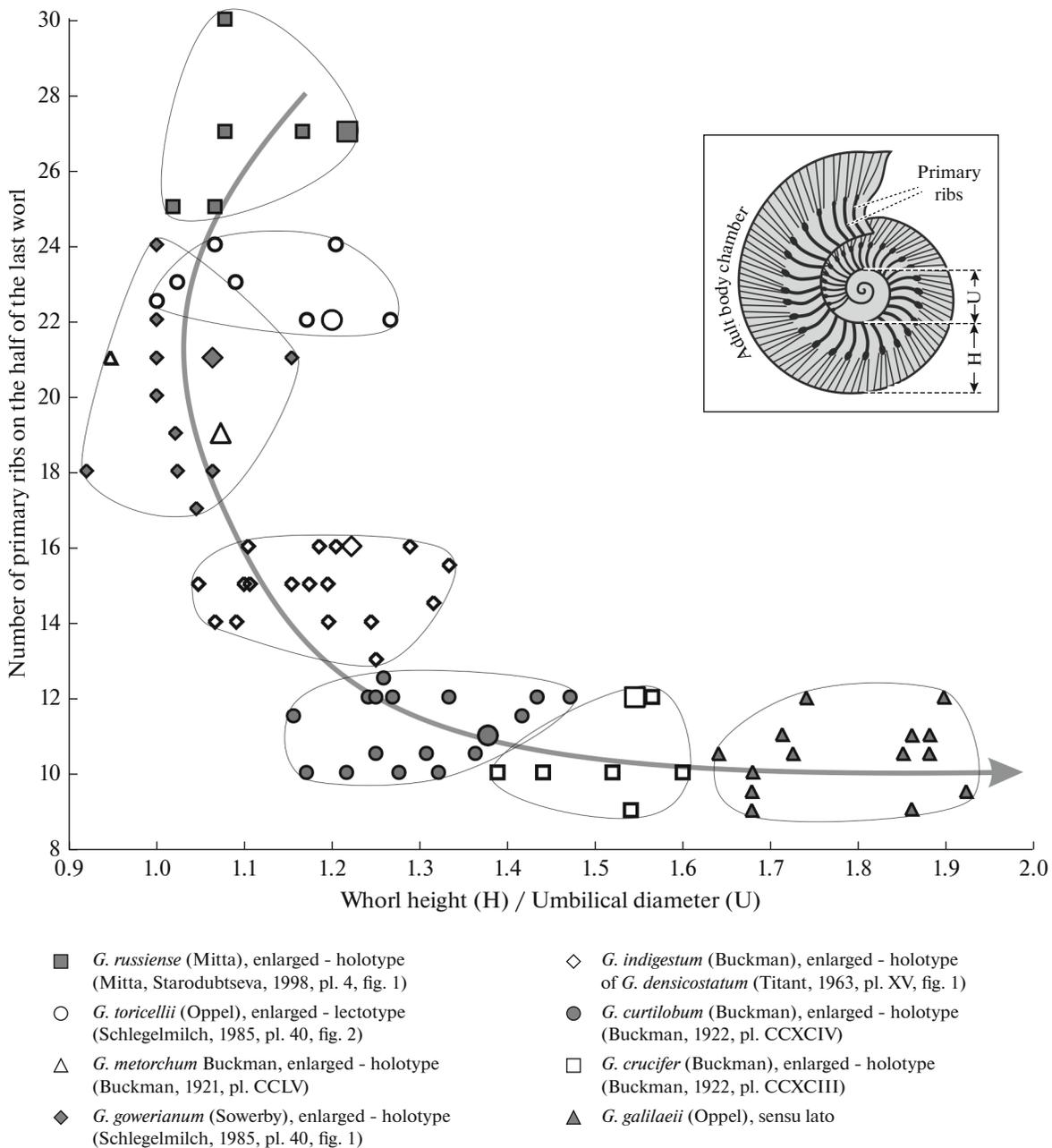


Fig. 18. Change in areas of features (Bezier curves) of adult shell in evolution of *Gowericereras*.

intense flow of cold Arctic water mass through the East European basin (Gulyaev, 2005b). It was recently suggested that the predecessors of *Gowericereras* could have migrated secondarily at the end of the Elatmae phase to the Boreal–Atlantic basins from the North Pacific province (Mönnig and Dietl, 2017). No reliable *Gowericereras* and generally Kosmoceratids, however, were found in the Lower Callovian on a vast and well-studied intermediate territory of Northern Siberia and the Canadian Arctic. A single ammonite shown as “?*Gowericereras* sp.” from the

“Lower Callovian” talus of the Anabar Bay (Melidina, 1977, pl. 17, fig. 2) evidently belongs to the Valanginian Polyptychitidae Wedekind.

The *Gowericereras* phyloline links species *G. russiense*¹⁰ [incl. *G. unzhae* (Gulyaev)] → *G. toricellii* (Oppel) →

¹⁰It is likely that *G. hildesheimense* (Tintant) from the upper parts of the Herveyi Zone of North Germany is a senior subjective synonym or direct descendant of *G. russiense* (Tintant, 1963; Mönnig and Dietl, 2017). To date, however, it is characterized only by an incomplete core of an adult body chamber, which hampers a full correct comparison.

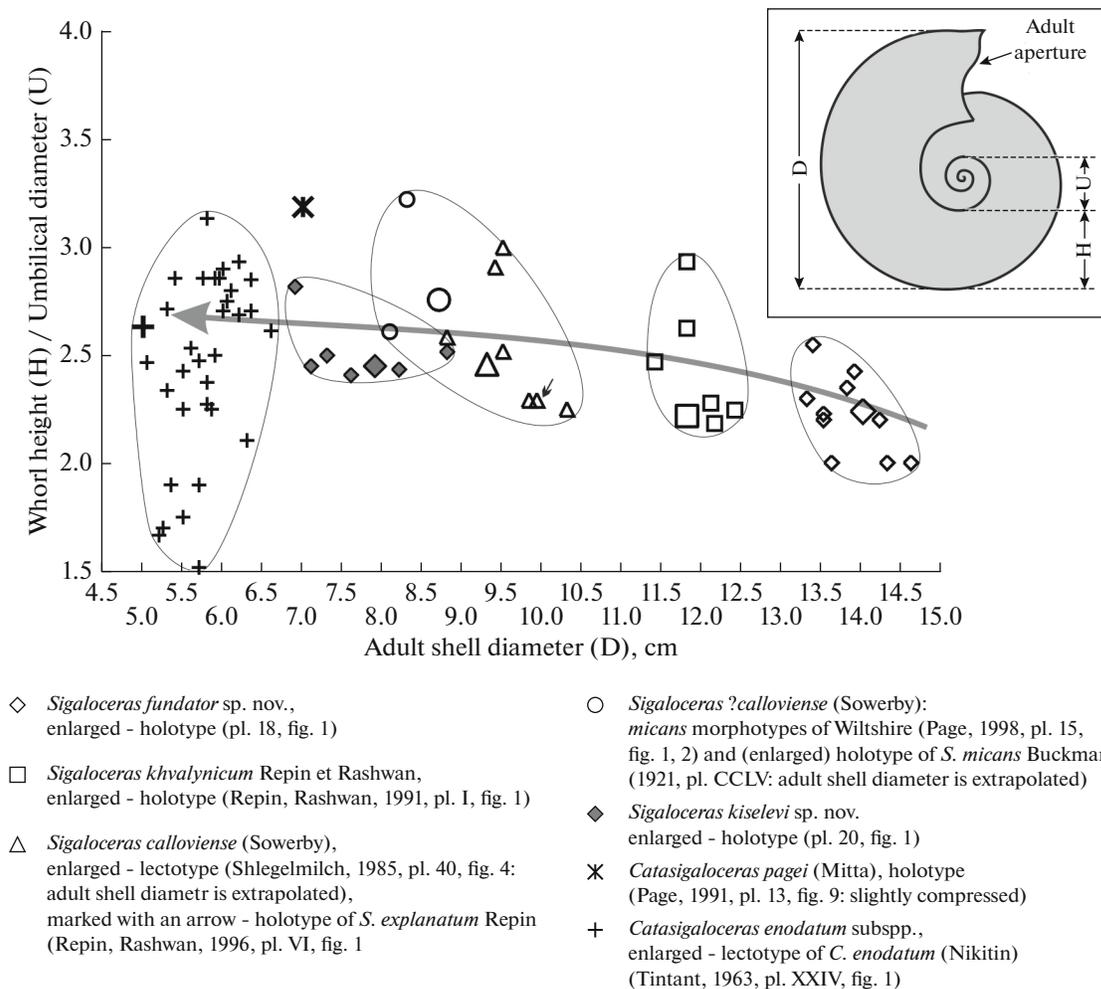


Fig. 19. Change in areas of features (Bezier curves) of adult shell during evolution transition from *Sigaloceras* to *Catasigaloceras*.

G. metorchum Buckman → *G. gowerianum* (Sowerby) → *G. indigestum* (Buckman) [incl. *G. densicostatum* (Tintant)] → *G. curtilobum* (Buckman) → *G. crucifer* (Buckman) → *G. galilaeii* (Oppel) sensu lato (Figs. 15, 18). The most pronounced changes in it are related to a gradual increase in the differentiation of ribs, the relative height of the whorls, and the involute character of the shell. The ribbing (the range of species *G. russiense*–*G. indigestum*) and the form of the shell (the range of species *G. curtilobum*–*G. galilaeii*) mainly change at the initial and further evolution stages, respectively. The ribbing character is well recorded even on strongly deformed specimens, which are prevail in the Lower Callovian of Kanev dislocations. Especially obvious evolutionary changes of ribs are observed on the last adult whorl, which exhibits a gradual enlargement and rarefaction of primary ribs, which finally transform (*G. galilaeii*) to wide gentle folds, whereas the secondary ribs become thinner and denser. The young (inner) whorls of successive representatives of *Gowericeras* are characterized by increas-

ingly thinner and denser secondary and primary ribs. The earliest forms (*G. russiense*, *G. hildesheimense*, and *G. toricellii*) also have unevenly high lateral spiny tubercles and high densification of primary ribs near the adult aperture. The latter feature is also typical of *G. metorchum* and is less expressed in its descendant *G. gowerianum*, the biometric field of which generally includes *G. metorchum* in Fig. 18. Here, the latter representatives of *Gowericeras* transitional to *Sigaloceras* are conditionally ascribed to *G. galilaeii* s.l. They can potentially be ascribed to a new species, which was apparently outlined by Mönnig (2010) as *G. "copernici* n.sp. (MS)," whereas, in our work, it is also *G. aff. galilaeii* (Fig. 15).

During the evolution, the *Gowericeras* microconchs, which are ascribed to the genus *Toricellites* Buckman (Fig. 15), also progressively acquired thinner and more differentiated ribbing, as well as a more involute shell with flattened whorls.

The phyletic trends in the change in ribbing and the form of the shell are preserved in evolution of genus

Sigaloceras (successive to *Gowericeras*) (Figs. 15, 19) up to complete smoothing of ribs on the adult body chamber and a transitional platicone-to-discocone form of the shell. The decrease in the terminal adult size of the shell at a general fetalization (rejuvenation) of its shape, which includes also the increasing involuteness of the adult shell at the expense of abbreviation of late growth stages, is especially typical of the phyloline of *Sigaloceras*. This evolution process is widely known as pae-domorphosis and its variety related to a shift of the final of growth to the earlier ontogenesis stages is called progenesis (Calow, 1983). In the literature, the ammonites which reflect various evolution stages of the genus are known as “*Sigaloceras calloviense* (Sowerby)” or close species. They all are united by a certain resemblance of form and ribbing of the shell; however, according to the terminal adult size and increasing involuteness related to decreasing size, they can be subdivided into three successive species:

(1) *S. fundator* sp. nov., a large form with a terminal diameter of 13–15 cm (Plate 18, fig. 1; Plate 19, figs. 1, 2); (2) *S. khvalynicum* Repin et Rashvan, a medium form with a terminal diameter of 11–13 cm (Repin and Rashvan, 1991) (Plate 17, figs. 1–3); and (3) *S. calloviense* s.s., a form with a terminal diameter of 8.0–10.5 cm (Plate 18, fig. 2), which often exhibits a specific slightly expressed “scaphitoid” adult body chamber. This group also includes *S. explanatum* Repin (Repin and Rashvan, 1996) and, preliminarily, *S. micans* Buckman, the holotype of which has no adult body chamber and is difficult to recognize.

The species *S. kiselevi* sp. nov. is the last in the range of the subfamily Gowericeratinae (Plate 20, figs. 1–4). The adult diameter of the representatives of this species varies in a range of 6.5–9.0 cm, which, along with the degree of involuteness of the shell, makes it similar to the morphotype *S. micans*, to which the representatives of this new species were ascribed repeatedly (see synonymic in description). The species *S. kiselevi*, however, has typical features, which are similar to those of early *Catasigaloceras* (*C. pagei* (Mitta) and *C. enodatum planicerclus* Buckman). These are (1) atypically wide at the end adult body chamber and (2) peculiar panicle-like rib bunches on the adult body chamber, where the division of secondary ribs begins on a wide primary rib. Both of these features are probably a result of rapid progenetic evolution.

The microconchs of *Sigaloceras* belong to the genus *Gulielmina* Buckman (Fig. 15). At the level of evolution of first three macroconch species, their microconchs are quite similar between each other and are preliminarily considered here a single nominal species *G. quinqueplicata* Buckman (sensu lato). In turn, the microconch of *S. kiselevi* sp. nov.—*G. aplanata* (Tsyrovitch) (Plate 20, figs. 5, 6) is significantly smaller and has finer ribbing relative to the predecessor microconchs of the group *S. calloviense-micans*

(*G. quinqueplicata*, s.l.) and, at the same time, well differs in sculpture from the microconchs of *Catasigaloceras*, which are ascribed to the genus *Gulielmiceras* Buckman (Plate 20, figs. 12, 13; Plate 21, figs. 4, 5, 9).

According to most features, the next genus *Catasigaloceras* belongs to subfamily **Kosmocerotinae** (Kiselev, 2001; Gulyaev, 2005a) (Figs. 15, 19). Its early species *C. pagei* (Plate 18, fig. 3) with relatively large size and archaic ribbing was not found in the Callovian of Kanev dislocations. Successive chronosubspecies *C. enodatum*¹¹ *planicerclus*¹² Buckman → *C. enodatum enodatum* (Nikitin) → *C. enodatum aeta* (Kiselev) in this range exhibit increasing features of early representatives of the Middle Callovian subgenus *Kosmoceras* (*Gulielmites*) Buckman (Kiselev, 2001). Because of extremely wide individual variability, which was a result of very fast evolutionary transformations (Fig. 19), however, the division of successive elements of this phyloline is typically possible only on numerous stratigraphically based materials. This is responsible for their correct nomenclature division only at the level of chronosubspecies. In contrast to the macroconchs, this division of the corresponding microconchs of the genus *Gulielmiceras* Buckman is much more expressed. The early microconchs, *G. distans* (Tintant), have prominent ribs and expressed lateral tubercles on the last adult whorl (Plate 20, figs. 5, 6), whereas the next microconchs, *G. anterior* (Brinkmann), are characterized by weakened ribs on the adult body chamber, higher section of whorls, and slightly larger (on average) size of the adult shell (Plate 21, figs. 4, 5, 9). Relying on these features, *G. anterior* is approaching to *G. gulielmi* (Sowerby), which is a microconch of the index species of the basal Zone of the Middle Callovian *Kosmoceras* (*Gulielmites*) *medea* Callomon.

In stratigraphy of the Koenigi Zone and the lower half of the Calloviense Zone of the Boreal–Atlantic Realm, the subordinate (but significant) role belongs to the ammonites of the subfamily **Proplanulitinae** (Fig. 15). The first reliable archaic representatives of this group were registered in the Ch. saratovensis (*G. toricellii*) Biohorizon of the Subpatruus Zone of the East European basin (Gulyev and Ippolitov, 2013; this work, Figs. 6, 9, 13; Plate 9, fig. 5) and an equivalent biohorizon of the Herveyi Zone of North Germany (Mönnig, 2014). According to numerous obser-

¹¹*Nautilus hylas* Reinecke is a possible senior synonym of *C. enodatum* (Reinecke, 1818, Tab. III, Figs. 24, 25), see (Dietl and Mönnig, 2016). The original of this almost unused species, however, is extremely poorly characterized, which makes impossible to identify even its dimorphic affinity.

¹²Kiselev (2001) denotes this chronosubspecies as *C. enodatum crispatum* Buckman. If we consider that *C. enodatum planicerclus* and *C. enodatum crispatum* are subjective synonyms, the name “*planicerclus*” is valid according to the principle of “first revised” (*Mezhdunarodny...*, 2004; article 24.2), i.e., J.H. Callomon (1955).

variations of Gulyaev, rare (up to 10% in complexes) perisphinctid ammonites, which are transitional between Grossouvriins and Proplanulitins, occur in the Central Volga region in the Subpatruus Zone beginning from the lowermost parts. These ammonites have never been specially studied and await their revision and description. They can indicate that the subfamily Proplanulitinae originated exactly in the East European marine basin in the Subpatruus phase and, from that period, they began to wide inhabit the whole Boreal–Atlantic Realm and adjacent basins.

Unfortunately, owing to the high variability and relatively weak level of study, no clear patterns of evolution of Proplanulitins have been identified. For example, if we consider only macroconchs, the Gowerian Subzone is dominated by relatively evolute coarsely ribbed forms with relatively wide whorls, which are more or less similar to *P. koenigi* (Sowerby). In the Curtilobum Subzone, Proplanulitins have a more involute flattened shell and finer less prominent ribbing, which, on average, correspond to the morphotype *P. ferruginosus* Buckman. The range from the end of the Curtilobum Subzone to the middle of the Calloviense Subzone is characterized by large evolute coarsely ribbed shells with wide whorls such as *P. crassiruga* (Buckman) and *P. crassicosta* (Buckman), which are sometimes combined into subgenus *Cras-siplanulites* Buckman. At the end of the Calloviense Subzone, the last representatives of proplanulitins are characterized by a relatively involute shell with high flattened whorls and typical weakly prominent ribbing: *P. irinae* Gulyaev (Gulyaev, 2001b). In the absence of Kosmoceratids, specific stratigraphic importance as a biohorizon index belongs to the microconch of *P. irinae* – *P. cracoviensis* Tornquist [m], in synonymic of which we consider here *P. fracidus* Buckman (used as index of the same biohorizon by (Kiselev, 2001)) and *P. rogoi* Gulyaev (extremely coarsely ribbed variety). It is possible that *P. cracoviensis* should include some specimens figured as *P. arciruga* Teisseyre (1887, Tab. IV, figs. 8, 9 only), while the holotype of the latter (Teisseyre, 1887, Tab. IV, fig. 5) is stands out by a wide umbilicus and frequent fine ribs (see also Buckman, 1922, CCCXXXI).

It is noteworthy that during the existence of Proplanulithins (Subpatruus and Koenigi phases, Calloviense subphase) in the East European Basin, their closest relatives and probable ancestors – representatives of the subfamily Grossouvriinae were almost absent (Fig. 15). At the same time, they were numerous and diverse in many basins of Western Europe. As was mentioned, the first rare Grossouvriins appear at the uppermost of the Elatmae Zone, in the P. vasily Biohorizon of Kanev dislocations (Figs. 6, 9; Plate 5, fig. 4; Plate 6, figs. 2–4) and C. tschernyschewi Biohorizon of the Unzha River (Fig. 14; Gulyaev, 2015c). They include rare poorly determined species of dimor-

phic pairs *Parachoffatia* Mangold [M]–*Homoeoplanulites* Buckman [m] and *Choffatia* Siemiradzki [M]–*Grossouvria* Siemiradzki [m]. In the Subpatruus Zone, they are replaced by relatively rare aforementioned forms transitional between Grossouvriins and Proplanulitins. The first occurrence of true Proplanulitins in the uppermost of the Subpatruus Zone—the lowermost of the Koenigi Zone, in the Ch. saratovensis (G. toricelli) and G. metorchum biohorizons, is accompanied only by rare Grossouvriins: *Homoeoplanulites* gr. *lobatus* (Buckman) (Plate 9, fig. 12) and corresponding large evolute macroconchs with absolutely smooth outer whorls (*Parachoffatia* sp.), which are currently almost unstudied.

Just after the extinction of Proplanulitins, Grossouvriins (the west pan-Tethyan immigrants) appear in a significant amount in the Enodatum Subzone of the East European basin, often, playing a subdominant and even dominant role in the ammonite assemblages. They also belong to two dimorphic genus pairs *Indosphinctes* Spath [M]–*Anaplanulites* Buckman [m] and *Choffatia* [M]–*Grossouvria* [m], the representatives of which require revision. The successive microconch species *A. difficilis* Buckman and *A. submutatus* (Nikitin) are especially important for the stratigraphy. The first one has large terminal sizes, less involute shell, and less reduced ribbing on the ventral side and young whorls. This allows to use it as an index of an alternative biohorizon in the lower part of the Enodatum Subzone in the case of poor characterization by Kosmoceratids (Figs. 15, 20).

The representatives of **Macrocephalitidae** are also important for the stratigraphy, especially, for the wide interregional correlation of the lower part of the Lower Callovian of the East European province. The lower part of the Callovian of the Standard European Stratigraphical Chart is subdivided exactly on the basis of Macrocephalitids. The ammonites of this Tethyan family spread to the territory of the East European basin at the very beginning of the Callovian (Gulyaev, 2001a, 2005a, 2007, 2015a, 2015d; Gulyaev and Ippolitov, 2016; Gulyaev and Rogov, 2009; Kiselev and Rogov, 2007; etc.). Although they remained relatively few in number, they reached the northernmost part of the basin (basins of the Pechora and Sysola rivers) and even formed a specific neoendemic phyletic line (Fig. 15): *Macrocephalites jacquoti* (H. Douville) → *M.* cf./aff. *jacquoti* (transient) → *M. multicostatus* (Paryshev) [incl. *M. menzeli* (Mönnig), *M. prosekensis* Gulyaev] → *M. pavlowi* Smordina [incl. *M. dietli* (Mitta)].

Mitta (1999, 2000, 2009, 2015); see also Howarth, 2017), combined the representatives of this phyloline into the genus *Eckhardites* Mitta, which he considers the descendant of *Arcticoceras* Spath and ascribes to high-Boreal subfamily Arctocephalitinae Meledina (family Cardioceratidae). These ideas contradict the

ZONE		North-Western Europe (modified after Callomon et al., 1988, 1989, 1992; Cox and Sumblar, 2002; Dietze et al., 2007; Mitta et al., 2015; Mönnig, 2014; Page, 1988, 1989; etc.; with updates according to Gulyaev, 2005; Kiselev, 2001)		Eastern Europe		Subzone	ZONE	
Sub-zone	Englamd	Germany	European Russia (Gulyaev, 2001a, 2005a, 2015d; Gulyaev and Ippolitov, 2013; Gulyaev et al., 2002; Kiselev, 2001; etc.; with updates)		Kanev dislocations area (present work)			
B i o h o r i z o n s								
CALLOVIENSE	Enodatum	?	?	C. enodatum aeeta	C. enodatum aeeta	Enodatum	CALLOVIENSE	
		C. enodatum enodatum [=enodatum γ] ('S. anterior')	C. enodatum enodatum [=enodatum γ]	C. enodatum enodatum	C. enodatum enodatum			
		C. enodatum planicerclus [=enodatum β]/A. difficilis	C. enodatum planicerclus [=enodatum β]	C. enodatum planicerclus	C. enodatum planicerclus			
	C. pagei [=enodatum α]	C. pagei	C. pagei	?				
	Calloviense	?	?Lacune	S. kiselevi	Pr. craco- viensis	S. kiselevi		Calloviense
		S. micans (sensu Page)		S. calloviense (incl. S. micans)		?		
		S. calloviense (s.l.)	S. calloviense (s.l.)	S. khvalynicum		S. khvalynicum		
				S. fundator		?		
	KOENIGI	Galilaei	"G. copernici MS" (sensu Mönnig, 2010)	"G. copernici MS" (sensu Mönnig, 2010)	"G. copernici MS" (sensu Mönnig, 2010)	G. galilaei (s.l.) [incl. "G. copernici MS" (sensu Mönnig, 2010)]		Galilaei
			G. galilaei (sensu Page, pars)	?Lacune	K. galilaei	G. crucifer [?=G. tricho- phorum (Buckm.)]		
Curtilobum		G. trichophorum [=G. gali- laei (sensu Buckman)]		[Parapatoceras level]	G. curtilobum	G. curtilobum	Curtilobum	
		Cad. tolype	O. subcostarius	G. curtilobum	G. curtilobum			
Gowe- rianum		G. indigestum [=G. curti- lobum (sensu Page)]	M. macrocephalius	G. indigestum	Ch. chamo- usseti (s.l.)	G. indigestum	Gowe- rianum	
		G. gowerianum		G. gowerianum	G. gowerianum			
	G. metorchum	G. metorchum / M. megalcephalius	G. metorchum	G. metorchum	G. metorchum			
HERVEYI	Kamptus	?	G. toricellii	Ch. saratovensis / G. Toricelli	Ch. saratovensis / G. Toricelli	SUBPATRUUS		
		M. polyptychus / M. kamptus γ	G. hildeshei- mense	M. kamptus	C-ch. uzhovkensis			
		M. kamptus β			C-ch. subpatruus			
		M. kamptus α / M. herveyi	Lacune		C-ch. surensis II			
	Terebratus	M. terebratus γ	M. terebratus		C-ch. surensis I			
		M. terebratus β			C-ch. tschernyschewi			
		M. terebratus α	P. wutachense	P. vasily		P. vasily		
	Keppleri	M. verus	P. suevicum [=P. elatmae]	P. elatmae		P. elatmae		
		?	P. quenstedtiforme	"P. chvadukasyense nom. provis."		Ammonites not found (?Lacune)		
		K. keppleri / M. jacquoti	K. keppleri / M. jacquoti	M. jacquoti	P. primaevum			
			P. poultoni					

Fig. 20. Infrazonal ammonite chart of the Lower Callovian of the area of Kanev dislocations (gray) and its correlation with charts of European Russian and Western Europe. A., Anaplanulites; C., Catasigaloceras; Cad., Cadoceras; Ch., Chamousetia; C-ch., Cadochamousetia; G., Gowericeras; K., Kepplerites; M., Macrocephalites; O., Oxycerites; P., Paracadoceras; Pr., Proplanulites; S., Sigaloceras.

following circumstances: (1) the complete absence of transitional forms between *Arcticoceras* and *Eckhardites* during the Middle and Late Bathonian and evident similarity of *Eckhardites* to Late Bathonian *Macrocephalites triangularis* Spath and *M. jacquoti* (H. Douville); (2) the abundance of the *Eckhardites* representatives in the southern and, especially, southwestern parts of the East European basin and their rarity at high latitudes (Gulyaev, 2015a; Gulyaev and Rogov, 2009); (3) features of the dimorphism of *Eckhardites* similar to *Macrocephalites* and strong difference from that of *Cardioceratids* (microconchs of *Eckhardites*, as well as morphologically similar *Macrocephalites*, have a relatively large involute discocone shell almost smooth on outer whorls, whereas microconchs of late *Arctoceras* (*Costacadoceras* Rawson [m]) are significantly smaller than the corresponding macroconchs (*Arcticoceras* Spath [M]) and have an evolute almost serpenticonic coarsely ribbed shell); (4) relative to the Bathonian–Callovian *Cardioceratids*, *Eckhardites* are characterized by an elongated ventral lobe and a shorter second lobe relative to the first side, which is typical, in particular, of *M. triangularis* (Datta et al., 1996); and (5) the representatives of *Eckhardites* have a thin highly differentiated (progressive feature) very gradually smoothed ribbing, the analogues of which are absent in modern them and earlier *Cardioceratids*, but are common in *Macrocephalites*. Thus, *Eckhardites* should be considered the subgenus *Macrocephalites*,¹³ and we should only determine its species composition, in particular, if it contains the Late Bathonian forms *M. gr. triangularis-jacquoti*.

A prerequisite for wide inhabitation and neoendemism of the discocone *Macrocephalites* in the East European basin was probably related to a deficit in these biomorphs in the oligotaxon ammonite community, which was strongly dominated by the representatives of the Boreal family *Cardioceratidae* with cadicone (macroconchs) and involute–serpenticonic (microconchs) shells. A gradual narrowing of the ventral side and reduction of the sculpture is observed during the evolution of the East European *Macrocephalites* (*Eckhardites*). This phyloline existed only during the Elatmae phase and the very beginning of the Subpatruus phase and became extinct when the *Cardioceratids*, which were preadapted to Subboreal conditions, formed a morphologically similar shell of *Cadochamousetia*. A wide propagation of *M. (Eckhardites)* to

the basins of Western Europe and Tethys was probably blocked by abundant closely related concurrent *Macrocephalites*.

The first member of the phyloline *M. jacquoti* (sensu stricto)¹⁴ is typical of the very beginning of the Callovian of the West and East European paleobiogeographic provinces. In both biochorems, this species can consist more than one-third of the ammonite complexes of the lower parts of the Herveyi Zone (Mönnig, 2014, 2017) and the lower part of the Elatmae Zone (Kiselev and Rogov, 2007), respectively. The evolution of its direct descendants, however, is different in the West and East European basins: *M. verus* Buckman with slightly coarser and longer persisting in ontogenesis sculpture in the West and *M. multicosatus* with finer smoothed sculpture and narrower ventral side in the East. The typical material of this species originates from the P. elatmae Biohorizon of Kanev dislocations (Paryshev, 1977; present work, Plate 3, figs. 1, 2). In the East European basin, the amount of *M. multicosatus* in the ammonite complexes of the P. elatmae Biohorizon is 8–14% and 3–6% in the southwestern and central parts, respectively (Gulyaev, 2015a, Fig. 1), whereas *M. verus* occurs rarely. At the same time, *M. verus* in Western Europe quantitatively often composes more than a half of the ammonites in complexes of the eponymous biohorizon and its stratigraphic equivalents (Callomon et al., 1988; Mönnig, 2014, 2017). Extremely rare representatives of *M. multicosatus* are found in this region only in North Germany (Mönnig, 2014) and a single published specimen was primarily described as *Chamousetia menzeli* Mönnig (Mönnig, 1995; present work, Plate 3, fig. 5). *M. prosekensis* Gulyaev (Gulyaev, 2001a) from the P. elatmae Biohorizon of the Central Volga region (present work, Plate 3, fig. 5) is probably a synonym of *M. multicosatus*. Very rare representatives of this species are found in the same biohorizon of the Pechora River basin (Gulyaev, 2007; Gulyaev and Ippolitov, 2016; present work, Plate 3, fig. 7). Moreover, they migrated even to the East Greenland province of the Arctic Realm: a specimen *M. multicosatus* was identified thanks to M.A. Rogov in the collection of J. Callomon (Copenhagen) from the P. cf. breve Biohorizon of the Jameson Land (present work, Plate 3, fig. 4). This ammonite is the only known representative of *Macrocephalites* found in Arctic. A narrow stratigraphic range, a wide geographical spread, and good recognition make *M. multicosatus* an excellent

¹³Multiple attempts at division of *Macrocephalites* into individual genera or subgenera, which were started by Buckman (1909–1930) in the 1920s, were ambiguous and are still waiting for a wide acceptance of the researchers (see Howarth, 2017), although, at any rate, the subgenus division of this diverse group, which lived for a long time (Middle Bathonian–Middle Callovian) on a vast territory (from Indonesia to East Greenland), was required long ago.

¹⁴A holotype of *M. jacquoti* (H. Douville, 1878, p. 570) [nom. nov. pro *Amm. macrocephalus compressus* Quenstedt (1847, Taf. 15, Fig. 1)] probably originates from the C. quenstedtiforme (=“C. quenstedti”) Biohorizon in the lower parts of the Callovian of South Germany (Callomon et al., 1989), although the early archaic (with stronger ribbing) representatives of this species appear in the Swabian Jurassic as early as the end of the Bathonian (Dietl, 1994; Dietze and Hostettler, 2015).

benchmark for a wide and precise interregional correlation (Gulyaev, 2015a).

The last element of this phyloline (*M. pavlowi*) is characterized by even more reduced sculpture and narrower ventral to acute early whorls (Gulyaev, 1999; Mitta, 2009; present work, Plate 7, figs. 1–3). This is unique among *Macrocephalites* and related Sphero-ceratid groups. The distribution of *M. pavlowi* is restricted. Its northernmost findings occur from the P. vasily Biohorizon of the south of the Komi Republic (Sysola River) (Gulyaev and Ippolitov, 2016). This species (terminal in the phyloline) was relatively long-lived (Gulyaev, 2012; present work, Fig. 15) much like a terminal species in the phyloline *Chamoussetia* (see above).

In the Callovian of Kanev dislocations, *Macrocephalites* are abundant only in the P. elatmae and P. vasily biohorizons. If, in addition to most typical endemic *M. multicostatus*, the first one contains the West European immigrant species of this family (*M. verus* Buckman (Plate 1, figs. 6, 7; Plate 2, figs. 3, 4) and *M. terebratus* (Phillips) (Plate 2, fig. 7)), the second one contains only *M. pavlowi*.

As was noted above, the heteromorphous ammonites of the genus *Parapatoceras* Spath (short-period (invasion) western pan-Tethyan migrant) are widely abundant in the Lower Callovian of the East European Platform (Gulyaev, 2002b; Mitta and Seltser, 2006; Gulyaev et al., 2015). They include *P. tuberculatum* (Baugier et Sauzé) and *P. distans* (Baugier et Sauzé), which occur in a stratigraphically narrow range in the lower part of the G. crucifer Biohorizon on a vast territory of Kursk, Kostroma, Nizhny Novgorod, Samara (unpublished), Saratov, and Orenburg (unpublished) oblasts. The invasion of *Parapatoceras* to the territory of England occurred approximately at the same time (Page, 1988; Colmon et al., 1988). Undoubtedly, these heteromorphs could not avoid the Dnieper–Donets basin; however, these heteromorphs were not yet been found in the Callovian of Kanev dislocations.

The possible presence of the western pan-Tethyan migrants of the genus *Bullatimorphites* Buckman (Tulitidae Buckman) was previously indicated in the lower part of the Lower Callovian (Gulyaev, 2015b). The ammonites from the collection of A.V. Paryshev (Institute of Geological Sciences, National Academy of Sciences of Ukraine, Kyiv), which were preliminary interpreted as *Bullatimorphites* (*Kheraicerus*) *bullatus* (d'Orbigny), however, require additional revision, because they can be deformed extremely inflated varieties of *Chamoussetia saratovensis* (Mitta, 2015).

Finally, we should conclude that the young East European marine basin in the beginning of the Callovian was an arena of neendemism of many ammonite groups. The Boreal-Atlantic (“western”) branch of the

subfamily Chamousetiinae originates here. Apparently, the genus *Gowericeras*, whose descendants are all later Cosmoceratids, is originated from here. There are grounds to believe that the subfamily Proplanulitinae originated exactly in this basin, as well as a specific Sub-boreal branch of Macrocephalitids (*Eckhardtites*). The Dnieper–Donets basin was not only a part of this intense neendemism diversification of ammonites but was also a way for their migration into marine basins of Western Europe.

DESCRIPTION OF AMMONITES

Below, we provide the description of new species of the genera *Paracadoceras* and *Sigaloceras*. The ammonite collection in this work is stored at the Ivanov Geological Museum (YSPU, Yaroslavl) except for specifically stated cases. The following abbreviations are used in tables of measurements: D, the diameter of the shell; Wh, the height of the whorl; Wb, the breadth of the whorl; U, the diameter of umbilicus; the stars mark the measurements near of terminal (adult) aperture.

FAMILY CARDIOCERATIDAE SIEMIRADZKI, 1891
SUBFAMILY CHAMOUSSETIINAE
ALEKSEEV ET REPIN, 1989

Genus *Paracadoceras* Crickmay, 1930

Paracadoceras vasily Gulyaev, sp. nov.

Plate 4, figs. 1, 3–5; Plate 5, fig. 1; Plate 6, fig. 1

Cadoceras tschernyschewi D. Sokolov: (pars) Mitta, 2000, pp. 44, 45, Pl. 21, fig. 2, ? Pl. 22, figs. 1, 2 (only).

Paracadoceras sp. nov. (aff. *elatmae* (Nikitin)): Gulyaev and Ippolitov, 2013, pp. 67, 69.

Paracadoceras cf. *vasily* nom. provis.: Gulyaev, 2015c, Pl. I, fig. 1.

Paracadoceras vasily nom. provis.: Gulyaev and Ippolitov, 2016, Pl. IV, fig. 1.

E t y m o l o g y. From a male name.

H o l o t y p e. YSPU, no. K/1729 (Plate 6, fig. 1), Cherkasy oblast, Kanev district, western (right) bank of the Kanev Reservoir (Dnieper River), Grigorovka-1 outcrop east of the settlement of Grigorovka (Figs. 1, 6, 9), the middle part of Bed 4; Elatmae Zone, P. vasily Biohorizon.

D e s c r i p t i o n. The shell is large (up to 11–12 cm), cadicone. The whorls are rounded–wide-trapezoidal, more expanding with growing shell. During ontogenesis, the umbilical wall changes from low moderately sloping with gradually reducing proximal elements of primary ribs to high moderately steep and steep smooth. The ribs on the young whorls are inclined forward, moderately prominent, mostly bifurcate at the height of the middle of the whorl, with simple and rare intercalated secondary ribs. At the diameter of the shell of 3.5–4.0 cm, the primary ribs on the venter become weaker and smoother. Up

to the diameter of 4.5–5.0 cm, the secondary ribs are typically lost or can be seen as weakly prominent folds. In this case, the primary ribs are initially preserved in the form of pronounced elongated forward sloping ridged tubercles. As the shell grows, the ribs become shorter and shorter and are individualized

(squeezed), transforming on the last whorl into elongated nodes-bullae, which are weakened near the terminal aperture.

Dimensions in mm and ratios (see also Fig. 17):

Specimen number	D	Wh	Wb	U	Wh/D	Wb/D	U/D
Holotype K/1729	103*	39	52	32	0.38	0.50	0.31
(slightly deformed)	91	40	50	26	0.44	0.55	0.29
K/1715	80	29	52	29	0.36	0.65	0.36
K/1714	41	15	18	14	0.37	0.44	0.34
3/1913	116*	42	62	39	0.36	0.53	0.34
	95	35	60	34	0.37	0.63	0.36

Variability. It is expressed in the relative width (inflation) of the shell, the relative width of the umbilicus and steepness of the umbilical walls of the terminal whorl, the density of ribs on young whorls, the beginning and termination of their smoothing, and the amount and the degree of squeezing of bullae on the terminal whorl.

Comparison. In contrast to the ancestral *P. elatmae* (Nikitin), this species differs in a narrower umbilical funnel and steeper umbilical walls of the terminal whorl, lower amount and greater squeezing of bullae on it, and generally thinner and earlier smoothed ribbing of young whorls. In contrast to the descendant *Cadochamoussetia tschernyschewi* (Sokolov), it differs in a wider umbilical funnel with less steep walls and higher amount and less squeezed bullae on the terminal whorl. This species is similar to *P. wutachense* (Mitta et al.), but has a narrower umbilical funnel at the medium and late stages of growth of the shell.

Remarks. The microconch of this species (Plate 4, fig. 2) is morphologically similar to “*Pseudocadoceras mundum* (Sasonov). It is possible that this poorly preserved form was described by (Paryshev, 1977) as “*Quenstedtoceras furcacostatus*, sp. nov.”

Distribution. The Lower Callovian, Elatmae Zone, P. vasily Biohorizon of Central Ukraine and the central (the basin of the Unzha River) and northern (the basin of the Sysola River) parts of European Russia.

Material. More than ten variously preserved specimens from the Grigorovka-1 (Bed 4) and Monastyrk-2 (Bed 4) sections, about 15 specimens from outcrops at the Unzha River (Pezhenga, Manturovo, Makaryev), and two specimens from a section near the settlement of Votcha at the Sysola River.

FAMILY KOSMOCERATIDAE HAUG, 1887

SUBFAMILY GOWERICERATINAE BUCKMAN, 1926

Genus *Sigaloceras* Hyatt, 1900

Sigaloceras fundator Gulyaev, sp. nov.

Plate 18, fig. 1; Plate 19, figs. 1, 2

? *Sigaloceras* (*Sigaloceras*) *calloviense* (Sowerby): (part) Meledina, 1987, pp. 27, 28, Pl. VII, fig. 2 (only); Repin and Rashvan, 1996, pp. 27, 28, Pl. II, fig. 1; Pl. XVI, fig. 1 (only).

Sigaloceras (*Sigaloceras*) *calloviense* (Sowerby): Mitta, 2000, Pl. 67, figs. 1, 2; Gulyaev, 2001a, Pl. V, fig. 4 ($\times 0.7$).

Sigaloceras calloviense (Sowerby): Gulyaev, 2013b, Plate, fig. 4 ($\times 0.8$); Keupp and Mitta, 2013, Fig. 9.5; ?Gründel and Mitta, 2013, Pl. 2, figs. 1, 2.

Kepplerites (*Gowericeras*) *galilaei* (Oppel): Gulyaev, 2015c, Pl. III, fig. 1.

Etymology. From the Latin *fundator* (founder).

Holotype, YSPU, no. A/53 (Plate 18, fig. 1); Nizhny Novgorod oblast, Lyskovo district, a quarry near the settlement of Prosek, the upper parts of Bed 4 (Rogov et al., 2012; Fig. 3); Calloviense Zone, Calloviense Subzone, condensed *S. fundator* Biohorizon. It was previously shown as *Sigaloceras* (*Sigaloceras*) *calloviense* (Sowerby) (Gulyaev, 2001a, Pl. V, fig. 4).

Description. The shell is large (the terminal diameter of 13–15 cm at an average value of 14 cm), involute platicone. The whorls are highly trapezoidal with rounded–flattened venter, moderately steep umbilical seam, and a rounded umbilical margin. At the end of the adult (terminal) body chamber, the section of the whorl becomes lower rounded-trapezoidal. The umbilicus is moderately deep, narrowly stepped. The ribs on the inner whorls are fine and dense. On the innermost whorls (up to 2 cm in diameter), the primary ribs are bifurcate or trifurcate with irregular spinulose nodes in coarse-ribbed varieties. As the shell grows, the amount of ribs in branches increases, reaching 6–7 and more on the last whorl, and all the more numerous intercalated ribs appear. The sculp-

ture is strongly reduced on the adult body chamber: the primary ribs are transformed to wide flattened folds slightly enhanced near the aperture; in flattened varieties, these folds are poor; the secondary ribs are

transformed to striae, locally, again being enhanced near the aperture.

Dimensions in mm and ratios (see also Fig. 19):

Specimen number	D	Wh	Wb	U	Wh/D	Wb/D	U/D
Holotype A/53	140*	48	47	46	0.34	0.34	0.33
	106	47	42	23	0.44	0.40	0.22
7/1510	140*	41	41	50	0.29	0.29	0.36
	122	49	37	33	0.40	0.30	0.27
3/1548	134*	48	49	43	0.36	0.37	0.32
	105	47	43	23	0.45	0.41	0.22
3/624	113	46	45	28	0.41	0.40	0.25

Variability. There is a typical variability of a complex of positively related features of the width, evoluteness and ribbing coarseness of the shell. Varieties are presented on Pl. 19.

Comparison. From the predecessors *Gowericeras galilaeii* (Oppel) and *G. aff. galilaeii* (transitional form between *Keplerites* and *Sigaloceras* [?= *G. coopernici* MS sensu E. Mönnig (2010)]), this species differs in slightly finer ribbing of the inner whorls, a significantly reduced sculpture of the adult body chamber, and slightly larger and more involute shell. From the descendant *S. khvalynicum* Repin et Rashwan, it differs in larger size, less involute shell, and less reduced sculpture of the last whorl.

Remarks. The typical *Gulielmina quinqueplicata* Buckman is a microconch of the species described.

Distribution. The Lower Callovian, Calloviense Zone, Calloviense Subzone, S. fundator Biohorizon of Europe, East Caspian region (Tuarkyr, Mangyshlak), and East Greenland.

Material. About 30 variously preserved specimens from various regions of European Russia (mostly, the basins of the Unzha and Oka rivers and Central and Lower Volga regions).

Sigaloceras kiselevi Gulyaev, sp. nov.

Plate 20, figs. 1–4

Keplerites (*Sigaloceras*) *calloviensis* Sowerby: (part) Ammaniyzov, 1962, pp. 48, 49, Table III, fig. 1; Table XXVIII, fig. 4.

Sigaloceras (*Sigaloceras*) *micans* (Buckman): Mitta, 2000, Table 68, figs. 1, 2.

Sigaloceras (*Catasigaloceras*) *pagei* Mitta: Mitta, 2000, Table 68, figs. 3, 4.

Specimen number	D	Wh	Wb	U	Wh/D	Wb/D	U/D
Holotype Man/2-1	78*	30	30	22	0.38	0.38	0.28
	68	33	26	15	0.49	0.38	0.22
	45	20	17	10	0.44	0.38	0.22

Sigaloceras sp. nov. (aff. *micans* Buckman): Gulyaev and Ippolitov, 2013, pp. 68–70.

Sigaloceras micans (Buckman): Gründel and Mitta, 2013, pl. 2, figs. 6, 7; Keupp and Mitta, 2013, figs. 11.2.

Etymology. The species is named after a specialist on Jurassic ammonites and biostratigraphy Dmitry Nikolaevich Kiselev.

Holotype, YSPU, no. Man/2-1 (Plate 20, fig. 1); Kostroma oblast, the right bank of the Unzha River near the town of Manturovo; undivided condensed deposits of the Galilaeii and Calloviense subzones, Bed 3 after (Mitta, 2000, pp. 12, 13); the collections of D.N. Kiselev (2000).

Description. The shell is small (the terminal diameter of 6.5–9.0 cm at an average value of 7.5 cm) morphologically transitional from involute platicone to discocone. The whorls are highly trapezoidal with a rounded–flattened venter, a steep umbilical wall, and a narrow rounded umbilical margin. At the end of the adult (terminal) body chamber, the cross section of the whorl is rounded-rectangular to round. A relatively wide aboral part of the adult body chamber is a typical feature. The umbilicus is moderately deep and narrowly steeped. The ribs on the inner whorls are fine and very dense. On the innermost whorls (up to 2 cm in diameter), the primary ribs are bifurcate or trifurcate with small spinulose nodes in the furcation point. As the shell grows, the amount of ribs in branches increases to 8–10 and more in the last whorl, all the more numerous intercalated ribs form, and the nodes vanish. On the last whorl, the ribs form typical panicle-like branches, where the secondary ribs are first split on a wide enlarged primary rib.

Dimensions in mm and ratios (see also Fig. 19):

Variability. There is a relatively wide variability of the terminal size of the shell related to the intense progenetic transformations at this evolution stage of the group. In addition, as the whole family is characterized by variable positively related features of the width, evoluteness, and ribbing coarseness of the shell.

Comparison. From the ancestor *S. calloviense* (Sowerby) s.s. (incl. *S. micans* Buckman), this species differs in the lower terminal size, atypically wide aboral part of the adult body chamber, and specific panicle-like rib branches on the adult body chamber. From the descendant *Catasigaloceras pagei* (Mitta), it differs in a less involute shell, a wider ventral side, more prominent archaic ribbing on the adult body chamber, and finer and denser ribbing of the inner whorls.

Remarks. *Gulielmina aplanata* (Tsytovitch) (Plate 20, figs. 5, 6) is a microconch of this species first described from the Callovian deposits of Mangyshlak (Tsytovitch, 1912). A specimen figured in (Tsytovitch, 1912; Table II, fig. 9) is selected here as a lectotype.

Distribution. The Lower Callovian, Calloviense Zone, Calloviense Subzone, S. kiselevi Biohorizon of the Volga region, Central Ukraine, and East Caspian region (Tuarkeyr, Mangyshlak).

Material. Three variously preserved specimens from a type locality, six incomplete specimens from Beds 15–18 of the Lukovitsa-1 section, and two specimens from the lower part of Bed 7b of the TETs-5 section (the city of Saratov, Fig. 13).

DESCRIPTION OF BIOSTRATONS

The following is a description of zones, subzones, and biohorizons which are identified by ammonites in the Lower Callovian in the area of Kanev dislocations, as well as their correlation with zonal and infrazonal units of European Russia and Western Europe (Fig. 20) and, on some ranges, with the Boreal scale of East Greenland. The biostratons of the lower part of the Lower Callovian, which are most specific to the East European Platform and its adjacent territories, are considered in detail. The paleontological characterization of the biohorizons is given only for the area of Kanev dislocations.

Elatmae Zone Nikitin, 1881

Index species: *Paracadoceras elatmae* (Nikitin, 1878). Neotype, which was erroneously indicated by (Meledina, 1977, p. 70) as a lectotype (Mitta and Starodubtseva, 1998, p. 5), is figured in (Nikitin, 1881, Tab. XI (IV), fig. 20), refigured in (Mitta, 2000, Table 16, fig. 1), and stored at the CCRGPM (St. Petersburg, no. 34/1344); occurrence: the left bank of the Oka River near the town of Elatma, Ryazan oblast.

Author: Nikitin, 1881, p. 99 (as “Etag mit *Stephanoceras Elatmae*”).

Defined base: bottom of a clayey member of the Lower Callovian Elatma Formation in the section near the settlement of Prosek of Nizhny Novgorod oblast where it first appears *Macrocephalites jacquoti* (H. Douville) [=bottom of bed 2 in (Gulyaev, 2001a, Fig. 2; Rogov et al., 2012, Fig. 3), the bottom of bed 6 in (Kiselev and Rogov, 2007, Fig. 2)].

Paleontological characteristics. The ammonites of the Elatmae Zone are generally dominated by the representatives of the high Boreal family Cardioceratidae Siemiradzki, which typically composes no less than 80% (often >90%). The ammonites of this family belong to subfamilies Chamoussetiinae Alekseev et Repin and Cadoceratinae Hyatt, which synchronously evolved during the Late Bathonian and Early Callovian. The first subfamily includes a rapidly evolved phyloline eudemic for the East European marine basin (macroconchs are listed): *Paracadoceras poultoni* Gulyaev → *P. primaevum* (Sasonov) → *P. chvadukasyense* nom. provis. → *P. elatmae* (Nikitin) → *P. vasily* sp. nov. → *Cadochamousetia tschernyschewi* (Sokolov). The successive phylogenetic biohorizons are based by these species (Fig. 15). Cadoceratinae also represents a single phyloline, which evolved slowly. Its successive elements differ from each other only in numerous material. Thus, most of them (macroconchs) were previously considered the chronosubspecies *Cadoceras “quenstedti* Spath” (Gulyaev, 2005a, 2007). It is revealed at present that the holotype of this species belongs to the Middle Bathonian *Bullatimorphites* Buckman (Tulitidae Buckman) (Mitta et al., 2015). Thus, the East European representatives of *Cadoceras* s.s. are considered *C. falsum* Voronez and *C. simulans* Spath (Gulyaev, 2015d, present work, Fig. 15) from the lower and middle parts of the Elatmae Zone, respectively, and *C. sp. nov.* (aff. *simulans*) (Gulyaev, 2015c, 2015d, Pl. I, figs. 4, 5) from its upper part. Within the entire range and the entire territory of occurrence of the Elatmae Zone, Chamoussetiinae usually are strongly dominant over Cadoceratins. Only in the “*P. chvadukasyense*” provis. Biohorizon *C. simulans* dominant over the parallel species *Paracadoceras*, which has not formally been described yet. It is noteworthy that exactly this period was characterized by a short-time invasion of *Cadoceras* s.s. on the territory of Germany, where the “*C. quenstedti*” Biohorizon (Callomon et al., 1988) is now replaced by the *C. quenstedtiforme* Biohorizon (Mitta et al., 2015; Mönnig, 2017; Mönnig and Dietl, 2017).

The basement of the Elatmae Zone (as well as its entire range) contains the representatives of the Tethyan family Macrocephalitidae Salfeld (Gulyaev, 1999, 2001a, 2005a, 2015a, 2015d; Gulyaev and Rogov, 2009; Kiselev and Rogov, 2007). They reach even the northernmost part of the Zone: the basins of

the Vychegda and Pechora rivers (Gulyaev, 2007; Gulyaev and Ippolitov, 2016). The relative abundance of *Macrocephalites* in the ammonite complexes is typically less than 5–10% and rarely exceeds 15–20%. The representatives of a specific phyloline eudemic for the East European marine basin are most typical of the complexes of the Elatmae Zone: *Macrocephalites jacquoti* (H. Douville) → *M. cf./aff. jacquoti* (transient) → *M. multicostatus* (Paryshev) → *M. pavlowi* Smorodina, which originates from the West Tethyan immigrant. It is interesting that the second to last element of this phyloline typical of the *P. elatmae* Biohorizon reached far into the Boreal basins, including East Greenland (Gulyaev, 2011, 2015a; present work, Plate 3, fig. 4). Mitta (1999, 2000, 2009) refers these ammonites to the genus *Eckhardites* Mitta, 1999 of the subfamily Arctocephalitinæ Meledina (family Cardioceratidae). These conclusions, however, definitely contradict the morphology and biogeography of the representatives of this phyloline (see above). The morphological features leave no doubts on the relation of these ammonites to the direct descendants of Tethyan Middle(?)–Upper Bathonian forms from the *Macrocephalites triangularis* Spath group (see Jain, 2014, 2020; Krishna and Westermann, 1987). In addition to *Macrocephalites* of this phyloline, the Elatmae Zone also contains other representatives of this family. Their maximum diversity is registered in the best studied *P. elatmae* Biohorizon (Gulyaev, 1999; Gulyaev and Rogov, 2009; Kiselev and Rogov, 2007). It contains both West European immigrants (*M. verus* Buckman, *M. terebratus* (Phillips)) and forms known only on the territory of the East European Platform (*M. volgensis* Gulyaev (Plate 1, figs. 6, 7; Plate 2, figs. 1–4, 7)).

While Cardioceratids and Macrocephalitids characterize the entire range of the Elatmae Zone, almost on the entire territory of its occurrence (no *Macrocephalites* have been found yet in the C-ch. tschernyschewi Biohorizon of the Pechora River basin), the representatives of other ammonite groups occur only in certain ranges and limited areas.

The ammonites of the low-Boreal subfamily Gowriceratinae Buckman (family Kosmoceratidae Haug) are identified only in the lowermost parts of the zone and its upper part. In first case, they include rare (less than 10% in complex) *Kepplerites* ex gr. *keppleri* (Oppel) [M] and *Toricellites* sp. [m], which occur in the lower parts of the *M. jacquoti* Biohorizon of the Central Volga region (Gulyaev, 2001a, 2005a, 2015d; Kiselev and Rogov, 2007). In second case, after the break in no less than three biohorizons, they appear as a dimorphic pair *Gowriceras russiense* (Mitta) [M] and *Toricellites unzhenensis* Mitta [m]. These species occur in the C-ch. tschernyschewi Biohorizon terminal for the Elatmae Zone in the basin of the Unzha River (Gulyaev, 1999, 2001a, 2005a, 2015c; Mitta, 2000; Mitta and Starodubtseva, 1998), where they

compose ~10%, on average, of the ammonite complexes. Single findings of similar poorly preserved forms are recorded in the former *P. vasily* Biohorizon in the area of Kanev dislocations (Plate 5, figs. 2, 3), in the basin of the Sysola River, and, probably, in the basin of the Unzha River (Gulyaev and Ippolitov, 2016; Mitta, 2000).

The ammonites of pan-Tethyan subfamily Grosouvriinae Spath (family Perisphinctidae Steinmann) first appear on the territory of the East European Platform in the *P. vasily* Biohorizon of Central Ukraine (Plate 5, fig. 4; Plate 6, figs. 2–4). The first single findings of the representatives of this group on the territory of European Russia are registered only in next C-ch. tschernyschewi Biohorizon of the basin of the Unzha River (Gulyaev, 1999, 2001a, 2005a, 2015c).

Composition. Six successive biohorizons¹⁵ are established by species of the *Paracadoceras*–*Cadochamousssetia* phyloline: *P. poultoni* Gulyaev, 2005 [=C. breve Kiselev et Rogov, 2007]; *P. primaevum* Gulyaev, 2005 [=C. frearsi Kiselev et Rogov, 2007]; “*P. chvadukasyense*” provis. [=C. falsum Mitta, 2000; =*P. elatmae anabarensis* Gulyaev, 2005; =C. quenstedti sensu (Kiselev et Rogov, 2007)]; *P. elatmae* Gulyaev et Kiselev, 1999; *P. vasily* Gulyaev, nov. [=C. tschernyschewi Mitta, 2000 (pars)]; C-ch. tschernyschewi Gulyaev, 1999 [=C. stupachenkoi Mitta, 2000]. The lowest two biohorizons correspond to the Biohorizon *M. jacquoti* Westermann et Callomon, 1988, which was first recognized together with the *M. verus* Biohorizon in South Germany (Swabia) (Westermann and Callomon, 1988, p. 16). The use of the *M. jacquoti* Biohorizon in the East European Platform is reasonable when the preservation (deformation) of the representatives of *Paracadoceras* in the section prevents identification of index species by the form of the shell, whereas the representatives of *Macrocephalites* are typically well recognized by ribbing even in deformed shells.

The Lower Callovian of Kanev dislocations contains only the *P. elatmae* and *P. vasily* biohorizons, which are divided from the underlying and overlapping deposits by significant hiatuses; an erosion and condensation level is observed between these biohorizons.

Correlation. By the presence of *M. jacquoti* and *K. ex gr. keppleri* in the lower Biohorizon of the Elatmae Zone, which are typical of the basal level of the Herveyi Zone of Western Europe (Callomon and Dietl, 2000; Callomon et al., 1988, 1989; Page, 1989), the bottom of the Elatmae Zone can be correlated with the basement of this zone of the West European stan-

¹⁵The biohorizons in works (Gulyaev et al., 2002; Mitta and Starodubtseva, 1998) are considered according to the previously adopted principles (Gulyaev et al., 2010; Rogov et al., 2012) as provisory and nomenclature not available, because they both were given in these publications without indication of the certain stratotypes.

dard, which corresponds to the lower boundary of the Callovian Stage.

Remarks. “Etage mit *Stephanoceras Elatmae*” was recognized by (Nikitin, 1881) for the lower horizon of Jurassic in vicinity of Elatma at the Oka River with index species and ammonites, which belong to *Macrocephalites* in current taxonomy. In the opinion of this author, this straton corresponded to the entire Lower Callovian. Later, the nomenclature and ideas on the volume and the correlation of the Elatmae Zone underwent multiple changes and refinements (see review in Gulyaev, 2001a). At present, this Zone is “officially” considered the lowermost zone of the Callovian of the East European Platform and is entirely compared with Herveyi Zone of the West European scale (*Unifitsirovannaya...*, 2012).

After recognition of the Upper Bathonian Infimum Zone in the Central Volga region, in a stratotypical section near the settlement of Prosek (Nizhny Novgorod oblast), which directly underlies the Elatmae Zone (Gulyaev and Kiselev, 1999), the question arose on the boundary of the latter. In the vicinity of Elatma, the Elatmae Zone occurs with erosion on the coastal marine Bathonian Moksha Formation (Meledina, 1987). The lowermost Callovian parts are absent here and/or are not characterized by ammonites. As a stratotype of the lower boundary of the Elatmae Zone, was suggested the bottom of a clayey member (Elatma Formation), which occurs without a visible hiatus on silty-sandy rocks (Lukoyanov Formation) of the Infimum Zone in the section near the settlement of Prosek (Gulyaev, 2001a, 2005a; Kiselev and Rogov, 2007). This level is characterized by the first occurrence of immigrant species *Macrocephalites jacquoti* on the territory of European Russia, which indicates the formation of a stable connection between the East European marine basin and seas of the western periphery of Tethys. At present, this level also characterized by *Paracadoceras poultoni* is traced in sections on a vast territory from the Lower Volga region to the basin of the Pechora River (Gulyaev, 2007, 2015d; Rogov et al., 2012, Fig. 6).

V.V. Mitta (Mitta, Starodubtseva, 1998; Mitta, 2000) singled out the Subpatruus Subzone from the classical volume of the Elatmae Zone and moved this Subzone into a structure of the overlying Gowerianum Zone. He relied on erroneous ideas that the Subpatruus Subzone corresponds to some hiatus between the Herveyi and Koenigi zones of the English Callovian. Later, Mitta (2000) refuted these ideas and considered the Subpatruus Subzone in the structure of the Elatmae Zone. Taking a large biostratigraphic volume of the Elatmae Zone (*sensu lato*, no less than ten successive phylogenetic biohorizons) and relying on a significant change in the taxonomic composition of the ammonite complexes at the boundary of the Elatmae and Subpatruus subzones (Gulyaev, 2005b), Gulyaev

et al. (2002) and Gulyaev (2005a) proposed to consider them independent zones. In such status they were included in the Boreal Zonal Standard of the Jurassic System (Zakharov et al., 2005; *Sostoyanie...*, 2008). This viewpoint was not reflected in the newest version of the Unified Regional Stratigraphic Chart of Jurassic Rocks of the East European Platform (*Unifitsirovannaya...*, 2012), but was supported by Dissenting opinions of some domestic specialists (*Unifitsirovannaya...*, 2012, pp. 42–43), as well as in the works of some German researchers (Mönnig, 2017; Mönnig and Dietl, 2017). In the present work, the Elatmae and Subpatruus zones are considered independent (see also Gulyaev, 2013a).

In the lower part of the Elatmae Zone, Mitta (2004b) recognizes the Keppleri Subzone, which is considered an equivalent of the eponymous subzone of the Herveyi Zone of the West European chart. As was shown before (Kiselev and Rogov, 2007; Gulyaev, 2013a, 2015d), to the “Keppleri Subzone,” Mitta ascribed the horizons with erroneously determined ammonites from the upper part of the Lukoyanovo Formation of the Central Volga region, which occurs below the level of occurrence of *M. jacquoti* and which belongs to the Upper Bathonian Infimum Zone.

Distribution: the European part of Russia, Central Ukraine.

Paracadoceras elatmae Biohorizon

Gulyaev et Kiselev, 1999

Index species: the same as that of the Zone.

Stratotype: the section near the settlement of Prosek (Lyskovo district, Nizhny Novgorod oblast). The published descriptions of this section are distinct from each other in details and the thickness of layers/interlayers (Gulyaev, 2001a; Gulyaev and Kiselev, 1999; Kiselev and Rogov, 2007; Rogov et al., 2012, Fig. 3). In 2013, the section was re-examined by the authors. The reliable range of occurrence of *Paracadoceras elatmae* was identified in a interval of 7–11 m above the bottom of a clayey member of the Lower Callovian Elatma Formation. It corresponds to a range from the basement of Bed 10 (after Kiselev and Rogov, 2007, Fig. 2) to the middle of Bed 2f (after Rogov et al., 2012, Fig. 3).

Stratotypical territory: the southeast of Nizhny Novgorod oblast.

Stratoethalons. The most complete section of the Elatmae Zone and its contact with underlying and overlapping rocks is observed in the upper–middle part of the Kostyanets Ravine in the area of Kanev dislocations, judging from the unpublished data of Paryshev (1969). We did not study this section. Preliminarily, the Grigorovka-1 section (Fig. 9) was chosen as a regional stratoethalon of the *P. elatmae* Bio-

horizon; however, its thickness is reduced and its lower part is unavailable in the section.

Paleontological characteristics.

Paracadoceras elatmae (Nikitin) [M] (Plate 1, figs. 1–4),

“*Pseudocadoceras*” *mundum* (Sasonov) [m] (Plate 1, fig. 5),

Cadoceras simulans Spath [M],

“*Pseudocadoceras*” sp. (large form) [m],

Macrocephalites multicostatus (Paryshev) [M&m] (Plate 1, fig. 8; Plate 2, figs. 5, 6; Plate 3, figs. 1, 2, 6)

Macrocephalites verus Buckman [M&m] (Plate 1, figs. 6, 7; Plate 2, figs. 2–4),

Macrocephalites terebratus (Phillips) [M] (Plate 2, fig. 7),

Macrocephalites volgensis Gulyaev [M] (Plate 2, fig. 1),

Macrocephalites spp. (coarsely ribbed forms) [M&m],

? *Homoeoplanulites*(?) ex gr. *furculus* (Neumayr) (Plate 1, fig. 9; Plate 2, fig. 8).

In the studied sections of Kanev dislocations, 85% of the ammonite complex of this biohorizon on average is composed of Cardioceratids. They include almost exclusively index species and its microconch “*Ps.*” *mundum*. Another parallel phyloline of Cardioceratids is characterized by sporadic (<1%) findings of *C. simulans* and its relatively large microconch “*Ps.*” sp., which belongs to an undescribed species. All these forms are generally typical of the *P. elatmae* Biohorizon of the East European Platform and its adjacent areas (Gulyaev, 2001a, 2005a, 2015d; Mitta, 2000). Among Macrocephalitids, which compose 15% of the ammonite complex on average, are dominated by fine-ribbed *M. multicostatus*, which is well identified even if it is poorly preserved and is a reliable reference for a wide and accurate interregional correlation from the Caucasus to East Greenland (Gulyaev, 2015a, 2015d). Most coarse-ribbed forms are similar to *M. verus*, which is typical of the upper part of the Kepleri Subzone of Western Europe (Callomon et al., 1988, 1989; Mönnig, 1995; Page, 1989). Unfortunately, the poor preservation and infrequent occurrence of coarse-ribbed *Macrocephalites* hampers their precise identification and determination of dimorphic affinity. Judging from the collection of K.M. Feofilaktov (NMNH, Kyiv) of the 19th century and the dissertation of A.V. Paryshev (1969), however, *Macrocephalites* of the *P. elatmae* Biohorizon of Kanev dislocations includes more than two species. For example, there are records of *M. terebratus* (Phillips), which is abundant in the eponymous West European Subzone (Callomon et al., 1988, 1989; Page, 1989); there are *Macrocephalites* indistinguishable from *M. volgensis* Gulyaev described in the *P. elatmae* Biohorizon of the Central Volga region (Gulyaev, 1999, 2001a). In addition, Feofilaktov’s collection contains a fragment of

the body chamber of *Homoeoplanulites*(?) ex gr. *furculus* (Grossouvriinae, Perisphinctidae), which was collected in the Kostyanets Ravine. Judging from the preservation and matrix, it probably originated from the described biohorizon, which is in agreement with the archaic features of the morphology of the ammonite. No reliable findings of Perisphinctids are known on the territory of the European Russia in the *P. elatmae* Biohorizon and underlying levels. At the same time, they are typical of an equivalent stratigraphic interval of Western Europe.

Correlation. This Biohorizon is correlated with the *C. suevicum* Biohorizon of Germany by *P. elatmae* [= *C. suevicum* Callomon et Dietl, 1989], *M. multicostatus* [= *Chamousetia menzeli* Monnig, 1995], and *M. verus* (Callomon et al., 1989; Mönnig, 1995, 2014, 2017); with the *M. verus* Biohorizon and the lowermost parts of the Terebratus Suzone of England by *M. verus* and *M. terebratus* (Callomon et al., 1988; Page, 1989); and with the *P. (cf./aff.) breve* Biohorizon of East Greenland by *M. multicostatus* [= *M. prosekensis* Gulyaev, 2001] (Callomon, 1993; Gulyaev, 2011, 2015a).

Remarks. The “*C. suevicum* α & β ” biohorizons are used in infrazonal charts of the Lower Callovian of Germany beginning from the period of their development at the end of the 1980s. The species *P. suevicum* was nominally established by J. Callomon and G. Dietl (Callomon et al., 1989, p. 5) by specimens shown in works (Quenstedt, 1847, Pl. 14, fig. 6 (holotype); 1887, Pl. 79, fig. 3; refigured in (Schlegelmilch, 1985, Pl. 41, fig. 12) as *C. cf. elatmae*). S.N. Nikitin (1878, pp. 57, 58) registered “identity” of features and “striking similarity” of the described by him *Amalth. Elatmae* and Swabian ammonite, which further became the holotype *P. suevicum*. Over the past decades, the Russian specialists, who well know the indigenous material, repeatedly expressed an opinion on the identity of *P. elatmae* and *P. suevicum* (Gulyaev, 2001a; Knyazev et al., 2010; Mitta, 2000; Sei and Kalacheva, 1992). Some German researchers, who have abundant collections for comparison, also saw no evident differences between these species (Mönnig, 1995). The “*C. suevicum* α ” and “*C. suevicum* β ” biohorizons were established in two adjacent interlayers with a total thickness of ~20 cm in a condensed interval of the section in the area of Blumberg-Zollhaus (Baden-Württemberg) (Callomon et al., 1989, Fig. 2). According to (Callomon et al., 1989, p. 7), the difference of these biohorizons is only related to slightly different ranges of variability of the index species. Later, the last form (“*C. suevicum* β ”) was recognized as a new species *P. wutachense* (Mitta et al., 2015), which became the index of the upper Biohorizon. Biometric studies show the identical key evolving features of South German *P. suevicum* s.s. and Central Russian *P. elatmae* (Fig. 17). These circumstances give grounds to use the

P. elatmae Biohorizon in Germany instead of the *C. suevicum* Biohorizon.

D.N. Kiselev (Kiselev and Ippolitov, 2011) correlated the sections of the Melanchin Ravine, Kostyanets Ravine, and Trakhtemirov, successively building them above each other. By representatives of *Macrocephalites*, in a range of the *P. elatmae* Biohorizon of Kanev dislocations, this researcher recognized three successive biohorizons: *M. cf. verus*, *M. multicostatus*, and *M. pavlowi*. As was shown above, the section of the Kostyanets Ravine is probably parallel to the lower part of the section of the Melanchin Ravine, but does not supplement it from the top. In each of these sections (taking into account the data of Kiselev), *M. cf. verus*, in fact, occurs below *M. multicostatus* (Fig. 4). The analysis of the data of A.V. Paryshev (1969) and materials of the collection of K.M. Feofilaktov on a more complete section of the Lower Callovian of the Kostyanets Ravine, however, does not support this pattern. The same is true for the sections of the northern part of the Kanev dislocations, where *M. ex gr. verus* occurs together with *M. multicostatus*. The range of the *M. pavlowi* Biohorizon in the Trakhtemirov section was recognized as the *P. vasily* nov. Biohorizon (see below).

Distribution. European part of Russia, Central Ukraine, Germany, Poland.

Occurrence: sections of the Melanchin Ravine, Kostyanets Ravine, Grigorovka-1, Lukovitsa-2, Monastyrek, Trakhtemirov.

Paracadoceras vasily Biohorizon

Gulyaev, nov.

Index species: *Paracadoceras vasily* Gulyaev, sp. nov. is described in this work.

Stratotype: Bed 4 of the Grigorovka-1 section (the contact of beds 3 and 4 also exhibits pocketlike holes up to 10 cm deep with clusters of ammonites of this biohorizon) (Fig. 9).

Stratotypical territory: the area of Kanev dislocations.

Stratoethalons. This biohorizon is also recognized in the basin of the Unzha River (Kostroma oblast, Kologriv, Manturovo, and Makaryev districts). As a regional stratoethalon for the Upper Volga region, it is proposed a section in a ravine near the village of Znamenka (Manturovo district, 58.3963° N, 44.8506° E), which was published in (Keupp and Mitta, 2013, Fig. 4; Gründel and Mitta, 2013, Fig. 2) and studied by the authors in 2014. The section needs to be restudied for the precise determination of stratigraphic ranges of index species (see below). A section near the settlement of Votcha on the Sysola River (Komi Republic) can be a stratoethalon of this Biohorizon for the northeast of the East European Platform (Gulyav and Ippolitov, 2016).

Paleontological characteristics.

Paracadoceras vasily sp. nov. [M] (Plate 4, figs. 1, 3–5; Plate 5, fig. 1; Plate 6, fig. 1),

“*Pseudocadoceras*” cf./aff. *mundum* (Sasonov) [m] (Plate 4, fig. 2),

Macrocephalites pavlowi Smorodina [M&m] (Plate 7, figs. 1, 2),

Gowericerias cf./aff. *russiense* (Mitta) [M] (Plate 5, fig. 2),

Toricellites cf./aff. *unzhensis* Mitta [m] (Plate 5, fig. 3),

Choffatia spp. [M] (Plate 5, fig. 4; Plate 6, fig. 2),

Parachoffatia sp. [M] (Plate 6, fig. 4),

Homoeoplanulites sp. [m] (Plate 6, fig. 3).

In the sections of Kanev dislocations, ~80% of the ammonite complex of the *P. vasily* Biohorizon consists of Cardioceratids. They include exclusively the index species and its microconch, which is close to “*Ps.*” *mundum*.

Macrocephalitids compose only ~4% of the ammonite complex and include only *M. pavlowi*, being the last element of a phyloline of this eudemic lineage of this family for the East European marine basin, which occurs in the Volga region sections up to the C-ch. *surensis* Biohorizon (Gulyaev, 1999, 2001a, 2005a, 2015a, 2015d; Gulyaev and Rogov, 2009; Kiselev and Rogov, 2007; Mitta, 1999, 2000, 2009). This species is also recorded in the *P. vasily* Biohorizon of the Sysola River (Gulyaev and Ippolitov, 2016).

Gowericeratins are also rare and compose ~4% of the ammonite complex. They include a dimorphic ammonite pair, which are similar to *G. russiense* [= *G. unzhae* (Gulyaev, 1999)] and *T. unzhensis* [= *T. pezhengensis* Gulyaev, 1999] established by V.V. Mitta in the basin of the Unzha River (Mitta and Starodubtseva, 1998). The remains of these ammonites in this Biohorizon are scarce, but if more complete material becomes available, they may be distinguishing into new species, the earliest of the reliable representatives of Gowericeratinae. The same biohorizon hosts a few first poorly preserved Gowericeratins in a section of the settlement of Votcha on the Sysola River (Gulyaev and Ippolitov, 2016).

Grossouvriins, which compose ~13% of the complex, include poorly preserved *Choffatia* and *Parachoffatia* species and their microconchs. These are the earliest reliable Perisphinctids in the Callovian of the East European platform.

Correlation. By the index species close to South German *P. wutachense*, the *P. vasily* Biohorizon is well compared with the *P. wutachense* Biohorizon of the German scale and, thus, with the middle part of the Terebratus Subzone of the Herveyi Zone of the standard West European scale.

Remarks. The “*Cadoceras tschernyschewi* Horizon,” which was established by Mitta (2000) at the Unzha River in the vicinity of the towns of Makaryev and Manturovo on the basis of erroneous interpretation of the representatives of the index species (see synonymic in description of *P. vasily* sp. nov.), is a synonym of the described biohorizon. Later, the “*tschernyschewi* faunal horizon” is shown by this author in the sections near the village of Znamenka (Manturovo district) without a precise stratigraphic range and image of findings of the index species (Keupp and Mitta, 2013, Fig. 4; Gründel and Mitta, 2013, Fig. 2). Our study of this section in 2014 showed the presence of *P. vasily* sp. nov.; however, the precise interval of occurrence of this species in clays of Bed 1 of the section remains unclear because of rare well-preserved findings suitable for unambiguous determinations.

Distribution: the north of Kanev dislocations, basins of the Unzha and Sysola rivers.

Occurrences: Grigorovka-1, Lukovitsa-2, Monastyrsk-2 and Trakhtemirov sections.

Subpatruus Zone Mitta, 1999

Index species: *Cadochamousetia subpatruus* (Nikitin, 1885). Lectotype is designated in (Mitta, 1999, p. 129), is figured in (Nikitin, 1885, Tab. (XI)XIII, fig. 58), is refigured in (Mitta, 2000, Table 31, Fig. 1), and is stored as nos. 38/1486 and 38a/1486 (collected by A.P. Pavlow, 1883) at the CCRGPM (St. Petersburg); the left bank of the Sura River, ?Sechenovo district, Nizhny Novgorod oblast.

Author: Mitta, 1999, p. 128 (as a subzone of the Gowerianum Zone).

Defined base. By the appearance of *Cadochamousetia surensis* (Nikitin) and *Gowericeras russiense* (Mitta) at the bottom of Bed 3b (3.1 m above the bottom of the Lower Callovian clays of Bed 3 of the Elatma Formation) in a quarry section near the settlement of Uzhovka, Pochinki district, Nizhny Novgorod oblast (Mitta, 1999, Fig. 1).

Paleontological characteristics. The representatives of the subfamily Chamousetiinae, which compose up to 80% or more of the ammonite complexes, are dominant among the ammonites of the Subpatruus Zone almost in the entire area of occurrence and stratigraphic range. The terminal Ch. saratovensis (G. toricellii) Biohorizon is the only exception where the amount of Chamousetiins cannot exceed 50% in the south of the Moscow Anticline (vicinity of the town of Mikhailov, Ryazan oblast), in the west of the Voronezh Anticline (vicinity of the town of Zheleznogorsk, Kursk oblast), and on the western slope of the Dnieper–Donets Trough (Kanev dislocations) (Gulyaev, 2005b). These territories belong to the biogeographically ecotone water area of the

Dnieper–Donets and the west of the Central Russian Jurassic marine basins.

The representatives of Chamousetiins continue a eudemic phyloline of the previous Zone: *Cadochamousetia surensis* (Nikitin) → *C-ch. subpatruus* (Nikitin) → *C-ch. uzhovkensis* Gulyaev → *Chamousetia saratovensis* Callomon et Wright. The listed species provide the basis for establishing of successive phylogenetic biohorizons (Fig. 15).

No reliable representatives of Cadoceratinae s.s. (*Cadoceras*) in the Subpatruus Zone are recorded. Recently published *Cadoceras bellabimba* Mitta (2016) from the “Chamousetia subpatruus Subzone” is washed out from the Lower Callovian condensed sands, which occur below the water level of the Unzha River near the town of Makaryev, and can originate from the terminal C-ch. tschernyschewi Biohorizon of the previous Elatmae Zone.

The terminal species of above described eudemic phyloline of *Macrocephalites* (*Eckhardites*) (*M. pavlowi* Smorodina) occurs only in the lowermost part of this Zone: in the lower part of the C-ch. surensis s.l. Biohorizon. This species typically comprises no more than 5–7% of the ammonite complexes.

The entire Subpatruus Zone contains the representatives of Gowericeratinae, which compose up to 15–20% of the ammonite complexes and up to 50% in the uppermost Ch. saratovensis (G. toricellii) Biohorizon of the western part of the area of the Zone. In the “Cadochamousetia’s” biohorizons, they are represented by a dimorphic pair *Gowericeras russiense* (Mitta) s.l. [M] and *Toricellites unzhensis* Mitta s.l. [m]. As was indicated, the macroconch species, at least, in the upper biohorizons can probably be ascribed to *G. hildesheimense* (Tintant). In the terminal biohorizon of the zone, it is replaced by a dimorphic pair *G. toricellii* (Oppel) [M] and *T. uhligi* (Parona et Bonarelli) [m].

In the greater part of the zone, Peresphinctids are represented by transitional forms between Grossouvriinae and Proplanulitinae, which have not been described yet. In the Central Volga region, there are rare “real” grossouvriins *Choffatia* spp. [M] and *Grossouvria* spp. [m]. In the uppermost part of the zone, true Proplanulitins appear, they represented by the as yet undescribed *Proplanulites* aff. *koenigi* (Sowerby) [M] and *Pr.* aff. *capistratus* Buckman [m]. In addition, Grossouvriins *Homoeoplanulites lobatus* (Buckman) [m] and its macroconch *Parachoffatia* sp., occur in the last biohorizon of the zone. The amount of Peresphinctids in all biohorizons of the Subpatruus Zone of the Volga region does not exceed 10%, reaching 20–30% or more in the C-ch. saratovensis (G. toricellii) Biohorizon of the western part of the area of the zone (Gulyaev, 2005b).

As seen from above, the boundary of the C-ch. *uzhovkensis* and C-ch. *saratovensis* (*G. toricellii*) biohorizons exhibits a significant rearrangement of the ammonite complexes of the East European marine basin, especially, in its western part. This rearrangement set the pattern for the evolution of the ammonite communities almost to the end of the Early Callovian. The next comparable change in the structure of the ammonite communities occurs in the middle of the Calloviense Zone.

Composition. Four successive biohorizons are established by species of the phyloline *Cadochamousetia*–*Chamousetia*: C-ch. *surenensis* Mitta, 1999, emend Gulyaev, 1999; C-ch. *subpatruus* Mitta, 1999, emend Gulyaev, 1999; C-ch. *uzhovkensis* Gulyaev, 2005 [=C-ch. *saratovensis* Mitta, 1999; =Ch. *saratovensis* Gulyaev, 1999 (2001); =Ch. *chamouseti* stuckenbergii Mitta, 2000 (etc.)]; and Ch. *saratovensis* Gulyaev, nov. [=Ch. *crobyloides* Gulyaev, 2005 (etc.)].

In the case of poor characterization of Cardioceratids, the latter phylogenetic biohorizon can be replaced by the *G. toricellii* Biohorizon Callomon et Dietl, 1988, the index species of which in most sections of the Lower Callovian of the East European Platform typically occurs together with *Ch. saratovensis*. The *G. toricellii* Biohorizon is known in several locations of South Germany and the north of Switzerland (Hausen (Killertal), Preffingen, Ebermannstadt) (Callomon et al., 1988, pp. 368, 369) and later was also identified in North Germany, Poland, and northeast France (Mönnig, 2014; Mönnig and Dietl, 2017).

In the Lower Callovian of Kanev dislocations, the largest part of the Subpatruus Zone is eroded and contains only its uppermost C-ch. *saratovensis* (*G. toricellii*) Biohorizon.

Correlation. By biostratigraphic successive position relative to the top of the Elatmae Zone, the bottom of the Subpatruus Zone is compared with the upper parts of the Terebratus Subzone of the West European scale. By the presence of *Gowericeras toricellii*, the uppermost part of this zone corresponds to the uppermost of the standard Herveyi Zone of continental Western Europe.

Remarks. After the identification of the Subpatruus Subzone in the Uzhovka section, V.V. Mitta (2000) included in it part of the “*C. stupachenkoi*” [=C-ch. *tschernyschewi*] Biohorizon, which was established by him at the Unzha River in vicinity of the town of Makaryev in Kostroma oblast. Gulyaev (2005a) also put the C-ch. *tschernyschewi* Biohorizon in the lower parts of the Subpatruus Zone, which was primarily established at the Unzha River in the Pezhenga section in the north of the Kologriv district of the Kostroma oblast (Gulyaev, 1999). In a stratotypical section near the settlement of Uzhovka and the entire stratotypical territory, which includes the southeast of the Nizhny Novgorod oblast, the northern part

of the Republic of Mordovia, and the west of the Chuvash Republic, however, a regional hiatus present between the *P. elatmae* and C-ch. *surenensis* biohorizons corresponds to the *P. vasily* and C-ch. *tschernyschewi* biohorizons (Gulyaev, 2015d). Thus, focusing on a biostratigraphic structure of the stratotype of the lower boundary, one should consider the C-ch. *surenensis* Biohorizon the basal one for this zone.

The C-ch. *surenensis* and C-ch. *subpatruus* biohorizons were independently established by Mitta (1999) in the Uzhovka section and by Gulyaev (1999) in the Uzhovka and Prosek-Isady (Lyskovo district of the Nizhny Novgorod oblast) sections. The understanding of index species of both authors is identical and the lists of accompanying ammonites are similar.

By key evolving features of the adult shell, *Cadochamousetia surensis* can potentially be divided into two chronosubspecies or species: early and late (more involute) (Fig. 17). The independent biohorizons, which are conditionally indicated as I and II in Fig. 20, should correspond to these species in the future. The nomenclature definitions, however, are hampered by impossible identification using these features of a lectotype of this species, which represents only young whorls (see above). It is noteworthy that the last representatives of *Macrocephalites pavlowi* occur only in conjunction with early form of *C. surensis*.

The index species of the C-ch. *uzhovkensis* Biohorizon was nominally established by Gulyaev (2005a, p. 66) as “*Cadochamousetia uzhovkensis* nom. nov. pro *C. saratovensis* (Callomon et Wright) sensu Mitta (1999), Gulyaev (1999, 2001a); holotype no. 5/1142 (Gulyaev, 2001a, Table IV, fig. 3).” The formal diagnosis was not initially provided, because this species (although with incorrect identification) was well characterized in cited works of Mitta and Gulyaev. The main difference between *C-ch. uzhovkensis* and *Ch. saratovensis* is related to an acute (keel) venter of the adult body chamber of the latter, which gives grounds to ascribe it to the *Chamousetia* R. Douville. By this feature, the ammonites from Uzhovka and vicinity of the town of Makaryev, which are shown by Mitta as “*Cadochamousetia saratovensis* (Callomon and Wright)” (Mitta, 1999, Figs. 6, 7) and “*Chamousetia chamouseti stuckenbergii* (Lahusen)” (Mitta, 2000, Table 39, figs. 1–3; Table 40, figs. 1, 2; Table 41, figs. 1, 2; Table 42, figs. 1–4 (only)), should be considered *C-ch. uzhovkensis*. *Ch. stuckenbergii* (Lahusen) evidently is a younger synonym of *Ch. chamouseti* (d’Orbigny) (Gulyaev, 2015d, p. 100; Gulyaev and Ippolitov, 2016, p. 238).

Distribution of the Subpatruus Zone is extremely uneven. Its main “*Cadochamousetia*’s” part is established only in the Central Volga region (mostly, northeast of Ryazan oblast, southeast of Nizhny Novgorod oblast, and Republics of Mordovia and Chuvashia) and in the Upper Volga region (southeast of Kostroma oblast, Makaryev district). No upper-

most *Ch. saratovensis* (*G. toricellii*) Biohorizon was identified in these regions. Without the rest of the zone, it occurs in the north of the Lower Volga region (Saratov right bank coast), the east of the Central Volga region (Samara Volga region and east of Orenburg oblast (see Nikitin, 1916, p. 12)), the north of the Upper Volga region (Kologriv district of Kostroma oblast (after P.G. Gerasimov, present work, Plate 8, fig. 5)), the west of Ryazan oblast (Mikhailov district), the north of Kursk oblast (Zheleznogorsk region), and Central Ukraine (Kanev dislocations).

***Chamoussetia saratovensis* Biohorizon**

Gulyaev, nov.

Index species: *Chamoussetia saratovensis* Callomon et Wright, 1989. Holotype is figured in (Sazonov, 1965, p. 38, Table IX, fig. 1) as “*Chamoussetia chamousseti* (d’Orbigny),” is refigured in (Mitta, 2000, Table 38, fig. 1) as “*Chamoussetia chamousseti stuckenbergii* (Lahusen),” and is stored in the Vernadsky State Geological Museum, Russian Academy of Sciences (Moscow), as no. VI-146/28; occurrence: Malinovy Ravine eastward of the village of Khlebnovka, Tatishchevo district, Saratov oblast.

Stratotype: Bed 1 of the TETs-5 section (Fig. 13).

Stratotypical territory: Saratov oblast.

Stratolithons. Beds 5–9 of the Grigorovka-1 section for the area of Kanev dislocations (Fig. 9). Lower 2.6–2.7 m of Bed 2 in the section of the Mikhailovka mine near the town of Zheleznogorsk of Kursk oblast (Tesakova et al., 2009, Fig. 2) for the western slope of the Voronezh Anteclise. Lower 4–5 m of Jurassic rocks occurring on the Carboniferous limestones in the southeastern part of the open pit near the settlement of Oktyabrskii of Mikhailov district of Ryazan oblast (section is not published) for the south of the Moscow Syncline.

Paleontological characteristics.

Chamoussetia saratovensis Callomon et Wright [M] (Plate 8, figs. 2–4),

Pseudocadoceras planum (Paryshev) [m] (Plate 8, figs. 6, 7),

Gowericeratites toricellii (Oppel) [M] (Plate 9, figs. 1, 2),

Toricellites uhligi (Parona et Bonarelli) [m] (Plate 9, fig. 4),

Proplanulites aff. *koenigi* (Sowerby) [M] (Plate 9, fig. 5),

Proplanulites aff. *capistratus* Buckman [m].

In the sections of Kanev dislocations, *Chamoussetiina* compose approximately half of the ammonite complex of the biohorizon. The remaining part belongs to *Gowericeratites* and slightly prevail *Proplanulitina*. At different levels (beds), the quantitative ratio of the ammonite subfamilies can vary within 10–20%.

Correlation. By the presence of *G. toricellii*, the *Ch. saratovensis* Biohorizon correlated to the *G. toricellii* Biohorizon of continental Western Europe. In England, this interval either is not characterized or is absent (eroded?) (Callomon et al., 1988; Mönnig, 2014, 2017; Mönnig and Dietl, 2017, Page, 1988).

Remarks. In papers (Gulyaev, 2005a; Gulyaev et al., 2002, etc.), this biohorizon was termed “*Ch. crobyloides*” for a long ago time. However, because of an unclear stratigraphic position and precise taxonomic affinity of a probably lost single specimen of *Amm. lamberti crobyloides* Quenstedt (Plate 8, fig. 1), *Ch. saratovensis* should be used for indexation of this biohorizon (see above). It is possible that *Ch. (?) recticostata* Paryshev, whose holotype represents a deformed specimen from the Lower Callovian of the Kostyanets Ravine, is a senior synonym of *Ch. saratovensis* (Paryshev, 1977, Table I, fig. 3).

Distribution: see description of the zone.

Occurrence: Grigorovka-1, Grigorovka-2, Lukovitsa-2, Monastyerk-2, and Trakhtemirov sections.

Koenigi Zone

Karitzky, 1887, emend 1890

Index species: *Proplanulites koenigi* (J. Sowerby, 1820). Lectotype was chosen by Buckman (1921, p. 36) and is figured in (Arkel, 1956, Pl. 37, fig. 4), Dorset, England.

Author: A.D. Karitzky (Karitzky, 1887, pp. 59–61; Karitzky, 1890, pp. 165, 166) as “(b) Perisphinct Subhorizon (Perisphinctes Koenigi Sow. Zone).”

Defined base. By the first occurrence of the index species in the sections of the northern part of Kanev dislocations: the base of Bed 10 in the Grigorovka-1 section (Fig. 9).

Paleontological characteristics. A phyloline of *Gowericeratites* is traced along the entire duration of the zone and along its entire area: *G. metorchum* Buckman → *G. gowerianum* (Sowerby) → *G. indigestum* (Buckman) [incl. *G. densicostatum* (Tintant)] → *G. curtilobum* (Buckman) → *G. crucifer* (Buckman) → *G. galilaei* (Oppel) sensu lato (Figs. 15, 18). Its representatives provide the most detailed basis for the infrazonal division. *Proplanulitina* and *Cadoceratites* evolved synchronously with *Gowericeratites*. *Chamoussetiina* occur only in the lower three biohorizons and most likely include one species *Chamoussetia chamousseti* (d’Orbigny) [= *Ch. stuckenbergii* (Lahusen), *Ch. hyperbolica* (Buckman), *Ch. phillipsi* Callomon et Wright, *Ch. buckmani* Callomon et Wright], which terminates the evolution of the subfamily in the Boreal–Atlantic paleobiogeographic realm. In the area of Kanev dislocations, this species is rarely found only in the lowermost *G. metorchum* Biohorizon. No other *Cardioceratites* in the Koenigi Zone are detected. There is single finding of *Gros-*

souvriins *Homoeoplanulites* cf. *lobatus* (Buckman) (Plate 9, Fig. 12).

Thus, the ammonite complexes of the described zone of Kanev dislocations are poor and most of them contain only Proplanulitins and usually prevail Gowericeratins.

Composition. The zone is subdivided into three subzones: Gowerianum Page, 1989; Curtilobum Page, 1989; and Galilaeii Page, 1989. The following biohorizons are recognized within their limits on the territory of the East European Platform: *G. metorchum* Callomon et Page, 1988 and *G. gowerianum* Callomon et Page, 1988 biohorizons in the Gowerianum Subzone; *G. indigestum* Callomon et Wright, 1989, *G. curtlobum* Gulyaev, 1999, and *G. crucifer* provis. biohorizons in the Curtilobum Subzone; and *G. galilaeii* Callomon et Page, 1988 (s.l.) Biohorizon in Galilaeii Subzone. All of them are present in the Callovian of Kanev dislocations (Figs. 15, 20).

Correlation. By guide ammonites, this zone completely corresponds to the West European standard.

Remarks. A question of priority of the establishment of the Koenigi Zone by A.D. Karitzky was previously considered in a historical review.

Distribution: Western and Eastern Europe, East Greenland, and Transcaspiian region (Mangyshlak).

Gowericereras metorchum Biohorizon

Callomon et Page, 1988

Index species: *Gowericereras metorchum* Buckman, 1921. Holotype figured in (Buckman, 1921, pl. CCLIV) and is stored at the British Geological Survey as no. GSM30456; occurrence: Kellaways Clay Member, Chippenham, Wiltshire, England.

Stratotype: the lower parts of the Kellaways Clay Member in the Cocklebury Hill section directly northeast of Chippenham, England.

Stratotypical territory: Wiltshire.

Stratoethalons. Beds 10 and 11 of the Grigorovka-1 section for the area of Kanev dislocations (Fig. 9). It is possible that, in this section, the index species continues to occur above, including the level corresponding to Layers 1–3 of the Grigorovka-3 section. This is evident from the range of *G. metorchum* in the Monastyrrek-2 section (Fig. 6).

Paleontological characteristics.

Gowericereras metorchum Buckman [M] (Plate 10, figs. 1–3),

Toricellites hexagonus (Loewe) [m] (Plate 10, figs. 4–7),

Proplanulites koenigi (Sowerby) [M] (Plate 9, fig. 11; Plate 10, fig. 8),

Proplanulites capistratus Buckman [m],

Homoeoplanulites cf. *lobatus* (Buckman) (Plate 9, fig. 12),

Chamoussetia chamousseti (d'Orbigny) [M] (Plate 9, fig. 6),

Pseudocadoceras boreale Buckman [m] (Plate 9, figs. 7–10).

Correlation. The Biohorizon of the standard West European Scale.

Distribution, Northwestern Europe, Central Ukraine, the west of Central Russia, ?East Greenland.

Occurrence: Grigorovka-1, Monastyrrek-2, and Trakhtemirov sections.

Gowericereras gowerianum Biohorizon

Callomon et Page, 1988

Index species: *Gowericereras gowerianum* (J. de C. Sowerby, 1827). Holotype (after monotype) figured in (Tintant, 1963, Pl. VII, fig. 1) and is stored at the British Museum as no. 43.917; occurrence: Brora, Sutherland, East Scotland.

Stratotype: an interlayer of nodules with *Cat-inula* in the lower parts of the Kellaways Clay Member; Somerford Keynes, Gloucestershire, England.

Stratotypical territory: Gloucestershire.

Stratoethalons. Beds 5–17 of the Grigorovka-3 section for the area of Kanev dislocations (Fig. 9). This index species probably also occurs slightly above in this section.

Paleontological characteristics.

Gowericereras gowerianum (Sowerby) [M] (Plate 10, figs. 1–3),

Toricellites approximatus Buckman [m] (Plate 10, figs. 5, 6),

Proplanulites koenigi (Sowerby) [M],

Proplanulites capistratus Buckman [m] (Plate 10, fig. 7).

Correlation. The biohorizon of the standard West European Scale.

Distribution: Northwestern Europe, Central Ukraine, European Russia, East Greenland.

Occurrence: Grigorovka-1, Grigorovka-2, Grigorovka-3, and ?Trakhtemirov sections.

Gowericereras indigestum Biohorizon

Callomon et Wright, 1989

Index species: *Gowericereras indigestum* (Buckman, 1922). Holotype figured in (Buckman, 1922, pl. CCCIX) and is stored at the Sedgwick Museum of Earth Sciences (University of Cambridge) as no. J 3310, occurrence: Kellaways Rock, Red Cliff, Scarborough, Yorkshire, England.

Stratotype: the middle part of the Kellaways Rock, Bed b2 after (Callomon and Wright, 1989,

pp. 800, 802; Wright, 1968, p. 372); Yorkshire coast, England.

Stratotypical territory: Yorkshire

Stratoethalons. Beds 1–4 of the Grigorovka-4 section for the area of Kanev dislocations (Fig. 12).

Paleontological characteristics.

Gowericeras indigestum (Buckman) [M] (Plate 12, figs. 1–3; Plate 13, figs. 1, 3),

Toricellites lahuseni (Parona et Bonarelli) [m] (Plate 12, fig. 5),

Proplanulites ferruginosus Buckman [M] (Plate 13, fig. 4),

Proplanulites excentricus Buckman [m] (Plate 13, fig. 5).

Correlation. By index species (see below), it corresponds to the “K. curtilobus” sensu Callomon and Page (Callomon et al., 1988) Biohorizon of England. By possible identity with *G. indigestum* and *G. densicostatum* (Tintant, 1963), it corresponds to the M. macrocephalus Biohorizon of South Germany (Callomon et al., 1992). By the presence of the last representatives of *Chamoussetia chamousseti* in this biohorizon of Central Russia, it corresponds to “Fauna 33. *Ch. phillipsi*” of East Greenland (Callomon, 1993).

Remarks. Judging from the analysis of ammonite images in (Page, 1989, Fig. 7.1) and an unpublished PhD Thesis (Page, 1988, pl. 12, figs. 1–3; pl. 13, figs. 1–3), *G. indigestum* (Buckman) and *G. curtilobum* (Buckman), according to this author, should belong to the same species, which is distinct from the holotype *G. curtilobum* (see below), which is the subsequent element of the *Gowericeras* phyloline (Fig. 18). J. Callomon (a coauthor of C.N. Page) (Callomon et al., 1988) also possibly erroneously understood *G. curtilobum*. In spite of incomplete preservation of the holotype *G. indigestum*, “*G. curtilobum*” of these researchers could be ascribed exactly to this species. In papers (Gulyaev, 1999, 2001a), this biohorizon was previously called as “K. densicostatus”; however, it seems that *G. densicostatum* is a junior synonym of *G. indigestum* (Fig. 18).

Distribution. Northwestern Europe, Central Ukraine, European Russia, Mangyshlak, East Greenland.

Occurrences: Grigorovka-2, Grigorovka-4, and Lukovitsa-1 (at the moment of field studies, below the water level) sections.

***Gowericeras curtilobum* Biohorizon**

Gulyaev, 1999, emend 2001

[non Callomon et Page, 1988, = biohorizon *G. indigestum* Callomon et Wright, 1989]

Index species: *Gowericeras curtilobum* (Buckman, 1922). Holotype figured in (Buckman, 1922,

pl. CCXCIV) and is stored at the British Geological Survey as no. GSM25691; occurrence: the Kellaways Formation, Kellaways, Wiltshire, England.

Stratotype: the middle part of Bed 4 (clayey silt with nodules of oolitic marl) in the section near the settlements of Prosek and Isady of Lyskovo district of Nizhny Novgorod oblast (Rogov et al., 2012, Fig. 3).

Stratotypical territory: southeast of Nizhny Novgorod oblast.

Stratigraphic references. Beds 5–10 of the Grigorovka-4 section and Beds 0–5 of the Lukovitsa-1 section for the area of Kanev dislocations (Fig. 12).

Paleontological characteristics.

Gowericeras curtilobum (Buckman) [M] (Plate 14, figs. 2, 3),

Toricellites curticornutus (Buckman) [m] (Plate 14, figs. 4–7),

Proplanulites ferruginosus Buckman [M] (Plate 15, figs. 2, 3),

Proplanulites excentricus Buckman [m].

Correlation. By the presence of the *Cadoceras tolype* Buckman in the stratotype of this Biohorizon, it is correlated with the C. tolype Biohorizon of England. By the identity of *Gowericeras* tinsleyi, it corresponds to “Fauna 34. *K. galilaeii*” of East Greenland (Callomon, 1993; specimen 3610, collection of J. Callomon, Copenhagen).

Distribution. Northwestern Europe, Central Ukraine, European Russia, Mangyshlak, East Greenland.

Occurrences: Grigorovka-2, Grigorovka-4, and Lukovitsa-1 sections.

***Gowericeras crucifer* Biohorizon** provis.

Index species: *Gowericeras crucifer* (Buckman, 1922). Holotype figured in (Buckman, 1922, pl. CCXCIII) and is stored at the British Geological Survey as no. GSM25692; occurrence: the Kellaways Formation, Kellaways, Wiltshire, England.

Stratotype: not chosen.

Stratotypical territory: not chosen.

Stratoethalons. The lower part of Bed 7 of the Lukovitsa-1 section (Fig. 12) for the area of Kanev dislocations.

Paleontological characteristics.

Gowericeras crucifer (Buckman) [M] (Plate 15, fig. 5),

Proplanulites sp. ind.

Correlation. By significant similarity of the inner whorls of the index species with a holotype *G. trichophorum* (Buckman), it is compared with the *G. trichophorum* Biohorizon of England.

Remarks. The biohorizon is conditionally described here as provisory, due to the impossibility of selecting a good stratotype within the scope of this work. In the area of Kanev dislocations, the range of occurrence of *G. crucifer* is small and is poorly characterized by ammonites; the same is true for the sections of the Saratov Volga region (Fig. 13). In the sections of the upper reaches of the Unzha River (Kologriv district), it was not separated during the field studies from the range of occurrence of the index species of the previous biohorizon (Fig. 14). The possible candidates of the stratotype could include either the sections of the Kellaways Formation in Wiltshire or those of the Koenigi Zone of the middle (Manturovo district) or lower (Makaryev district) reaches of the Unzha River. The presence of the heteromorphic ammonites *Parapatoceras* in the lower part of the biohorizon is its reliable mark (Gulyaev et al., 2015).

Distribution. Northwestern Europe, Central Ukraine, European Russia, Mangyshlak.

Occurrences: Lukovitsa-1 section.

Gowericeras galilaeii Biohorizon

Callomon et Page, 1988 (sensu lato)

Index species: *Gowericeras galilaeii* (Oppel, 1862). Lectotype was chosen and figured by S.S. Buckman (1922, pl. CCXC) (after Page, 1989, p. 374); occurrence: Chippenham, Kellaways, Wiltshire, England.

Stratotype: a boundary interval of the Kellaways Clay Member/Kellaways Sand Member (?), Chippenham.

Stratotypical territory: Wiltshire.

Stratolithons. The upper part of Bed 7—the lower part of Bed 11 of the Lukovitsa-1 section (Fig. 12) for the area of Kanev dislocations.

Paleontological characteristics.

Gowericeras galilaeii (Oppel) [M] (Plate 16, fig. 3),

Proplanulites ex gr. *crassicosta* (Buckman) [M],

Proplanulites ex gr. *petrosus* Buckman [m] (Plate 16, fig. 2).

Correlation. By index species, it corresponds to the Galilaeii Subzone of the West European Scale.

Remarks. *Gowericeras galilaeii* is one of the most ambiguous index species of the Lower Callovian scale and its understanding has been a matter of debate for more than a century. According to the biometric results (Fig. 18) and detailed study of sections (Fig. 12), this species evidently breaks up into early (corresponding to the lectotype chosen by S.S. Buckman) and late (more involute and fine-ribbed) forms. As was stated above, the latter can correspond to undescribed *G. "copernici* n. sp. (MS)," which was scheduled by E. Mönnig (2010). The early form from the sections near the settlements of Prosek and Isady was formerly described by Gulyaev (1999, 2001a) as "*K. trichophorus*."

Distribution: Northwestern Europe, Central Ukraine, European Russia, Mangyshlak.

Occurrences: Lukovitsa-1 section.

Calloviense Zone Oppel, 1856

Index species: *Sigaloceras calloviense* (J. Sowerby, 1815). Lectotype was chosen and figured by W.J. Arkell (1933, pl. XXXVI, fig. 5; 1956, pl. 37, Fig. 3) and is stored at the British Museum; occurrence: Kellaways Rock, Kellaways, Wiltshire, England.

Author: A. Oppel (1856).

Defined base: the base of the Kellaways Sand Member in the outcrops at the banks of the Avon River in the west of West Tytherton and south of Kellaways, Wiltshire.

Paleontological characteristics. The phyloline of Kosmoceratids (*Sigaloceras*–*Catasigaloceras*) is traced within the entire zone and almost in its entire area: *S. fundator* sp. nov. → *S. khvalynicum* Repin et Rashwan → *S. calloviense* (Sowerby) → *S. kiselevi* sp. nov. → *C. pagei* (Mitta) → *C. enodatum planicerclus* Buckman → *C. e. enodatum* (Nikitin) → *C. e. aeeta* (Kiselev) (Figs. 15, 19). Its representatives provide a most detailed basis for the infrazonal division. In the area of Kanev dislocations, Kosmoceratids are strongly dominant in the ammonite complexes of the Zone and are single representatives of this group of Cephalopods at many levels. The lower part of the zone (*S. khvalynicum* Biohorizon) also contains a few late representatives of Proplanulitins. The upper Enodatum Subzone contains the western immigrants (Grossouvriins), including the species of the genera *Choffatia* [M], *Indosphinctes* [M], and *Anaplanulites* [m], which occur only at local levels (Fig. 12) and rarely exceed 5–10% of the ammonite complexes. This is atypical, because Grossouvriins in the Enodatum Zone of the west of the Central Russian basin are often subdominant and dominant. Moreover, the Cadoceratinae so common for this Zone in Central Russia, in the area of the Kanev dislocations are represented only by a single find of *Novocadoceras* sp. ind. (Fig. 12). Thus, the Calloviense Zone of Kanev dislocations is even poorer in the ammonite complexes in comparison with the previous Koenigi Zone.

Composition. The Zone is subdivided into two subzones: Calloviense and Enodatum Brinkmann, 1929. The following biohorizons can be recognized by Kosmoceratids within their limits on the territory of the East European Platform: *S. fundator* provis., *S. khvalynicum* provis., *S. calloviense* provis., and *S. kiselevi* nov. biohorizons in the Calloviense Subzone; *C. pagei* Gulyaev, 2005 [non Mitta, 2000, =biohorizon *S. kiselevi* (pars.) (Gulyaev, 2005a, p. 67)]; *C. enodatum planicerclus* Gulyaev, 2005 [=biohorizon *C. e. crispatum* Kiselev, 2001 (Gulyaev, 2005a, p. 68)]; *C. e. enodatum* Callomon et Page, 1988, emend Kiselev,

2001; and *C. e. aeeta* Kiselev, 2001 in the Enodatum Subzone.

Most of these biohorizons occur in the Lower Callovian of Kanev dislocations.

Correlation. By guide ammonites, this Zone corresponds well to the West European standard.

Remarks. Most biohorizons of the Calloviense Subzone are indicated as provisory owing to the impossibility of selecting of a sufficient stratotype within the scope of this work. It is likely that these stratotypes occur in a unified section or a regional group of well comparable sections. The Lower Callovian rocks of England, Mangyshlak, or the lower–middle reaches of the Unzha River could serve for this aim.

Distribution: Western and Eastern Europe, East Greenland (pars.), Transcaspiian region (Mangyshlak, Tuarkyr (pars.)).

***Sigaloceras khvalynicum* Biohorizon** provis.

Index species: *Sigaloceras khvalynicum* Repin et Rashwan, 1991. Holotype figured in (Repin and Rashwan, 1991, Table I, fig. 1; Table II, fig. 1) and is stored at VNIGRI (St. Petersburg) as no. 1/847 [847/96]; occurrence: Dzharmysh-3 section [Bed 7 of the Dzharmysh-1 section], East Karatau Ridge, Mangyshlak (the data on the holotype figure in (Repin and Rashwan, 1996, Table III, fig. 1) are given in square brackets; they probably deserve more confidence, because, according to the description, no the Lower Callovian is exposed in the Dzharmysh-3 section).

Stratotype: not chosen.

Stratotypical territory: not chosen.

Stratoethalons. The middle–upper parts of Bed 11 of the Lukovitsa-1 section (Fig. 12) for the area of Kanev dislocations.

Paleontological characteristics.

Sigaloceras khvalynicum Repin et Rashwan [M] (Plate 17, figs. 1–3),

Proplanulites ex gr. *crassicosta* (Buckman) [M],

Proplanulites ex gr. *petrosus* Buckman [m].

Correlation. By index species, it corresponds to the middle part of the *S. calloviense* (sensu lato) Biohorizon of the West European Scale.

Distribution. Northwestern Europe, Central Ukraine, Volga region, Mangyshlak.

Occurrence: Lukovitsa-1 section.

***Sigaloceras kiselevi* Biohorizon** Gulyaev, nov.

Index species is described in this work.

Stratotype: Beds 15–18 in the Lukovitsa-1 section.

Stratotypical territory: the area of Kanev dislocations.

Stratoethalons. The lower half of Bed 7b in the TETs-5 section (Fig. 13) for the Saratov Volga region. The stratoethalons can also potentially be distinguished in the Kostroma Volga region (vicinity of the town of Manturovo), Tuarkyr, and Mangyshlak (see description of index species).

Paleontological characteristics.

Sigaloceras kiselevi sp. nov. [M] (Plate 20, figs. 2–4),

Gulielmina aplanata (Tsytovitch) (Plate 20, figs. 5, 6).

Correlation. By index species, it corresponds to the terminal part of the *S. calloviense* Subzone of the West European Scale.

Remarks. By collections from talus/landslide, V.V. Mitta (2000, pp. 13, 29) established the “micans” and “*Sigaloceras pagei*” “horizons” in the condensed rocks of the Koenigi and Calloviense zones at the Unzha River near the town of Mansurovo (Kostroma oblast). They both correspond to this biohorizon (see synonymic in description of *S. kiselevi* sp. nov.), although there is a doubt on possible identification of any horizons/biohorizons in these, probably, heterogeneous condensed rocks.

Distribution: Upper and Lower Volga region, Central Ukraine, Tuarkyr, Mangyshlak, ?England.

Occurrence: Lukovitsa-1 section.

***Catasigaloceras enodatum planicerclus* Biohorizon**

Gulyaev, 2005

Index species: *Catasigaloceras enodatum planicerclus* Buckman, 1923. Holotype figured in (Buckman, 1923, pl. CDXVII); occurrence: Kellaways Rock, South Cave, Yorkshire, England.

Stratotype: the upper third of the Cave Rock Member (corresponds to Beds 9 and 10 of the South Newbold Quarry section), South Cave Station Quarry, Humberside, England (Page, 1988, 1989).

Stratotypical territory: Humberside.

Stratoethalons: the upper part of bed 19–bed 27 of the Lukovitsa-1 section (Fig. 12) for the area of Kanev dislocations.

Paleontological characteristics.

Catasigaloceras enodatum planicerclus Buckman [M] (Plate 20, figs. 7–11),

Gulielmiceras distans (Tintant) [m] (Plate 20, figs. 12, 13),

Anaplanulites difficilis Buckman [m] (Plate 20, fig. 14).

Correlation. By the index species and *A. difficilis*, it corresponds to the *A. difficilis* and *C. enodatum* β biohorizons of the West European Scale.

Remarks. D.N. Kiselev (2001) established the *C. enodatum crispatum* Biohorizon; however, as was already mentioned, its name should change according to the principle of first revised.

Distribution: Northwestern Europe, Central Ukraine, European Russia, Mangyshlak.

Occurrence: Lukovitsa-1 section.

Catasigaloceras enodatum enodatum Biohorizon

Callomon et Page, 1988, emend Kiselev, 2001

Index species: *Catasigaloceras enodatum enodatum* (Nikitin, 1881). Lectotype (Nikitin, 1881, Tab. X(XIII), fig. 12) was chosen (primarily as a holotype), figured in (Tintant, 1963, Pl. 24, fig. 1), and further refigured in (Mitta, 2000, Table 69, fig. 1), and is stored at the CCRGPM (St. Petersburg) as no. 24/1344; occurrence: the Callovian rocks at the left bank of the Oka River near the settlement of Elatma (Ryazan oblast).

Stratotype: the lower 0–20 cm of the Peterborough section, Cambridgeshire, England.

Stratotypical territory: Cambridgeshire.

Stratoethalons: Beds 28–30 of the Lukovitsa-1 section (Fig. 12) for the area of Kanev dislocations.

Paleontological characteristics.

Catasigaloceras enodatum enodatum (Nikitin) [M] (Plate 21, figs. 1–3),

Gulielmiceras anterior (Brinkmann) [m] (Plate 21, figs. 4, 5),

Choffatia vischniakoffi (Teisseyre) [M] (Plate 21, fig. 6),

Indosphinctes mutatus (Trautschold) [M] (Plate 21, fig. 7),

Anaplanulites submutatus (Nikitin) [m],

Novocadoceras sp. ind. [m].

Correlation. By index species, it corresponds to the *C. enodatum* γ Biohorizon of the West European Scale.

Distribution: Northwestern Europe, Central Ukraine, European Russia, Mangyshlak.

Occurrence: Lukovitsa-1 section.

Catasigaloceras enodatum aeeta Biohorizon

Kiselev, 2001

Index species: *Catasigaloceras enodatum aeeta* (Kiselev, 2001). Holotype figured in (Kiselev, 2001, Table 1, figs. 4–6) and is stored at the A.N. Ivanov Geological Museum (YSPU, Yaroslavl) as no. E/M-12; occurrence: sandstone nodules at the boundary of Beds 5 and 6 in the section of the Oka River near the settlement of Elatma of Ryazan oblast (Kiselev, 2001, Fig. 1).

Stratotype: by locality of a holotype of the index species.

Stratotypical territory: Ryazan oblast.

Stratoethalons: Beds 31–33 of the Lukovitsa-1 section for the area of Kanev dislocations (Fig. 12).

Paleontological characteristics.

Catasigaloceras enodatum aeeta (Kiselev) [M] (Plate 21, fig. 8),

Gulielmiceras anterior (Brinkmann) [m] (Plate 21, fig. 9),

Anaplanulites submutatus (Nikitin) [m] (Plate 21, fig. 10).

Correlation. It probably corresponds to paleontologically poorly characterized Beds 9–10 in the basement of the stratotype of the Medea Subzone (Kidlington, England) (Kiselev, 2001, p. 22). It is the terminal biohorizon of the Lower Callovian.

Distribution: the basin of the Oka River, Central Ukraine,

Occurrence: Lukovitsa-1 section.

CONCLUSIONS

The main result of this work is the elaboration of the detailed zonal and infrazonal ammonite scale of the Lower Callovian of the area of Kanev dislocations including four zones, five subzones (in two upper zones), and 14 biohorizons, almost all of which have not been recognized on this territory before. The upper part of the Lower Callovian Substage, which composes two-thirds of its local biostratigraphic volume, was studied for the first time. It was established that the ideas on the presence of the Middle and Upper Callovian in the area of Kanev dislocations are erroneous. The recognition of these two substages is related to incorrect identification and/or interpretation of the age of ammonites by previous researchers. Our scale is perfectly correlated with zonal and infrazonal scales of European Russia and Western Europe and, in certain ranges, with the Boreal scale of East Greenland. It is established that the base of the *Proplanulites koenigi* Zone, which was established by A.D. Karitzky (1887) in the sections of the northern part of Kanev dislocations, biostratigraphically corresponds to the basement of the eponymous Zone established by S.S. Buckman (1913) in Northern Yorkshire and used in the Standard (chronostratigraphic) chart of Europe. Thus, the *Koenigi* Zone of Karitzky has both a nomenclature priority and a biostratigraphic volume similar to the *Koenigi* Zone of Buckman.

The system, evolution and biogeography of ammonites of the families *Cardioceratidae*, *Kosmoceratidae*, *Perisphinctidae*, and *Macrocephalitidae* distributed in the Early Callovian in the East European marine basin were revisited and analyzed. The biometric methods were used for the study of the evolution features of some biostratigraphically important phylolines. It is shown that, at the beginning of the Callovian, a vast young epicontinental East European

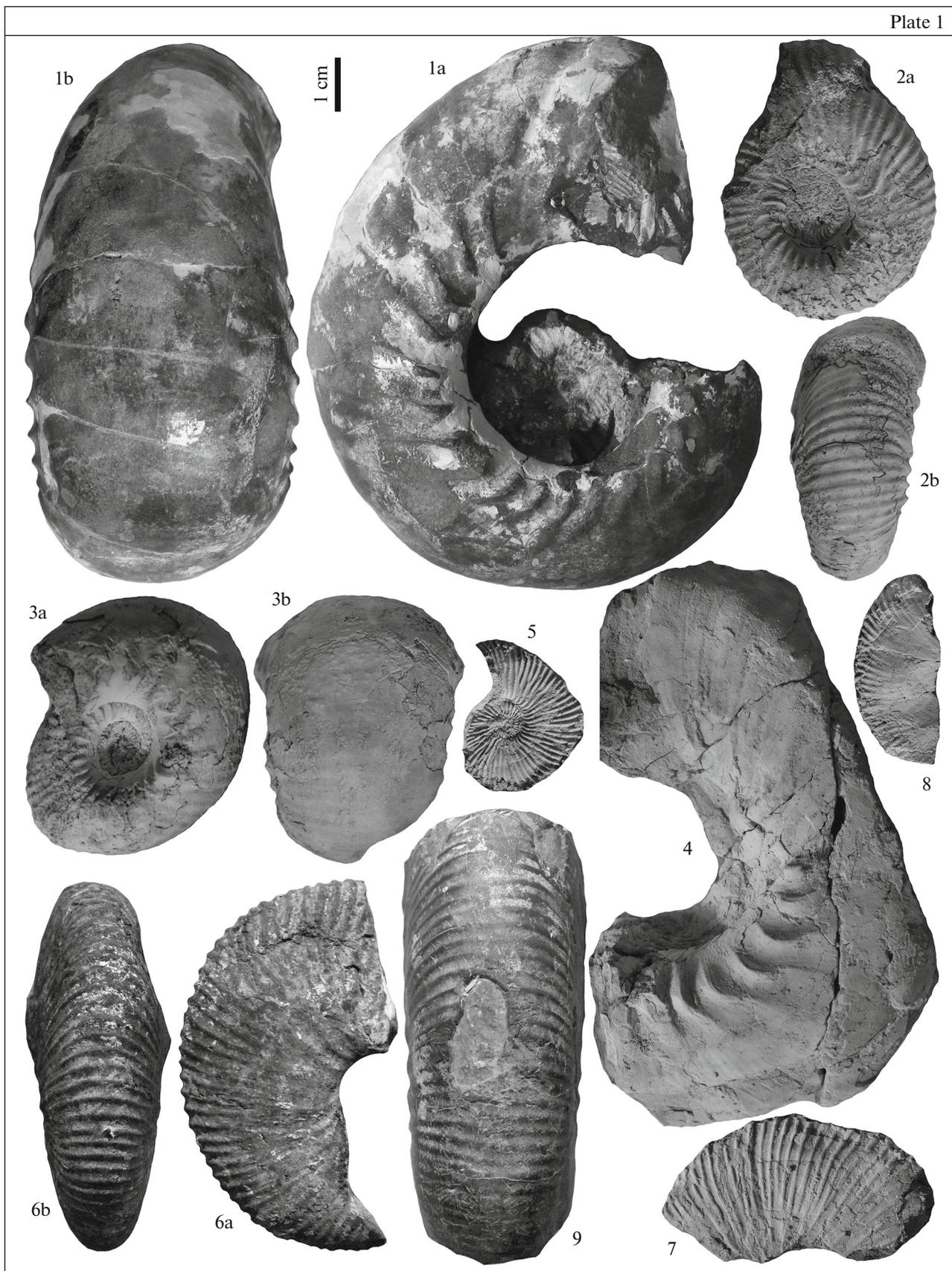
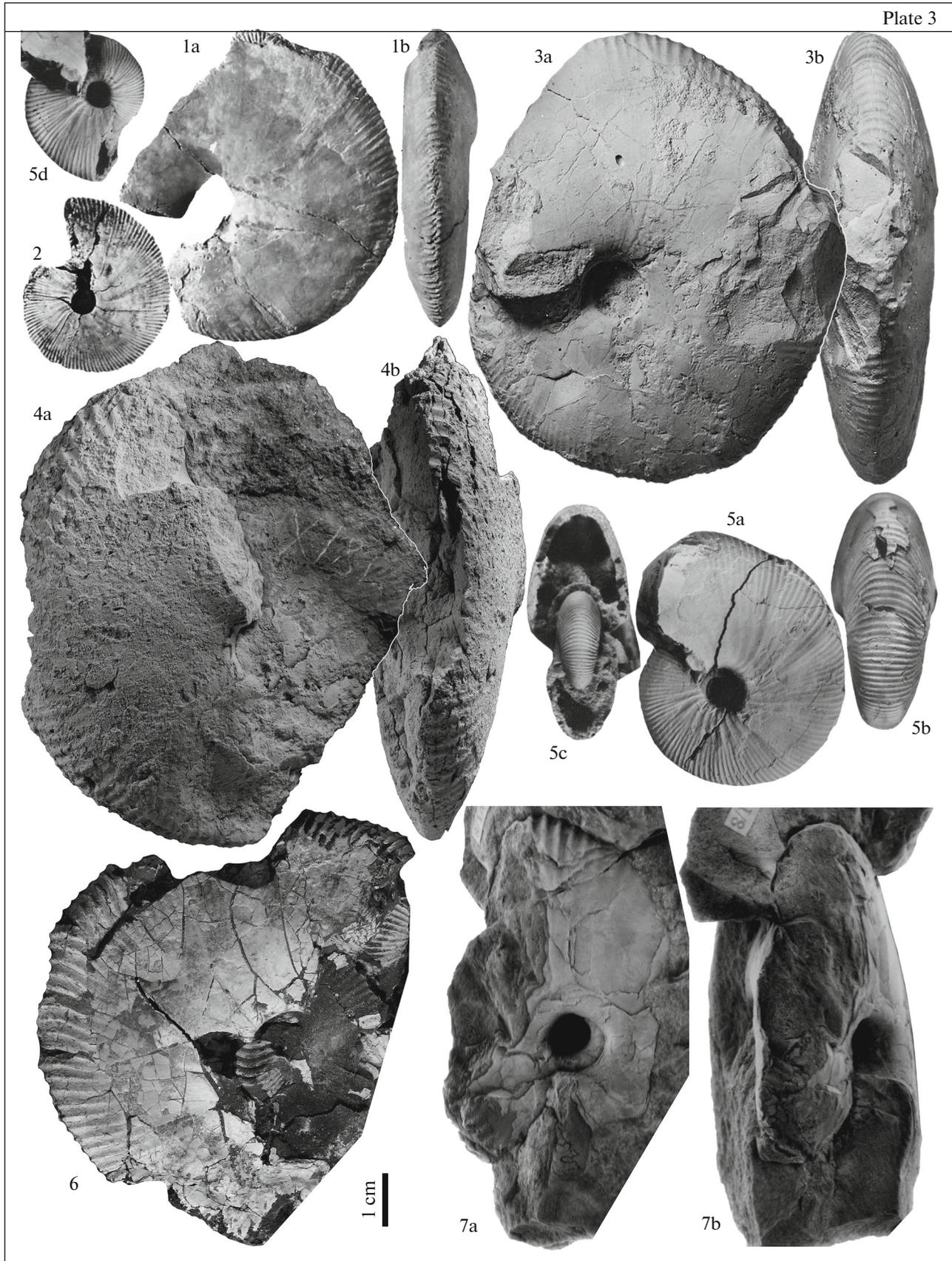
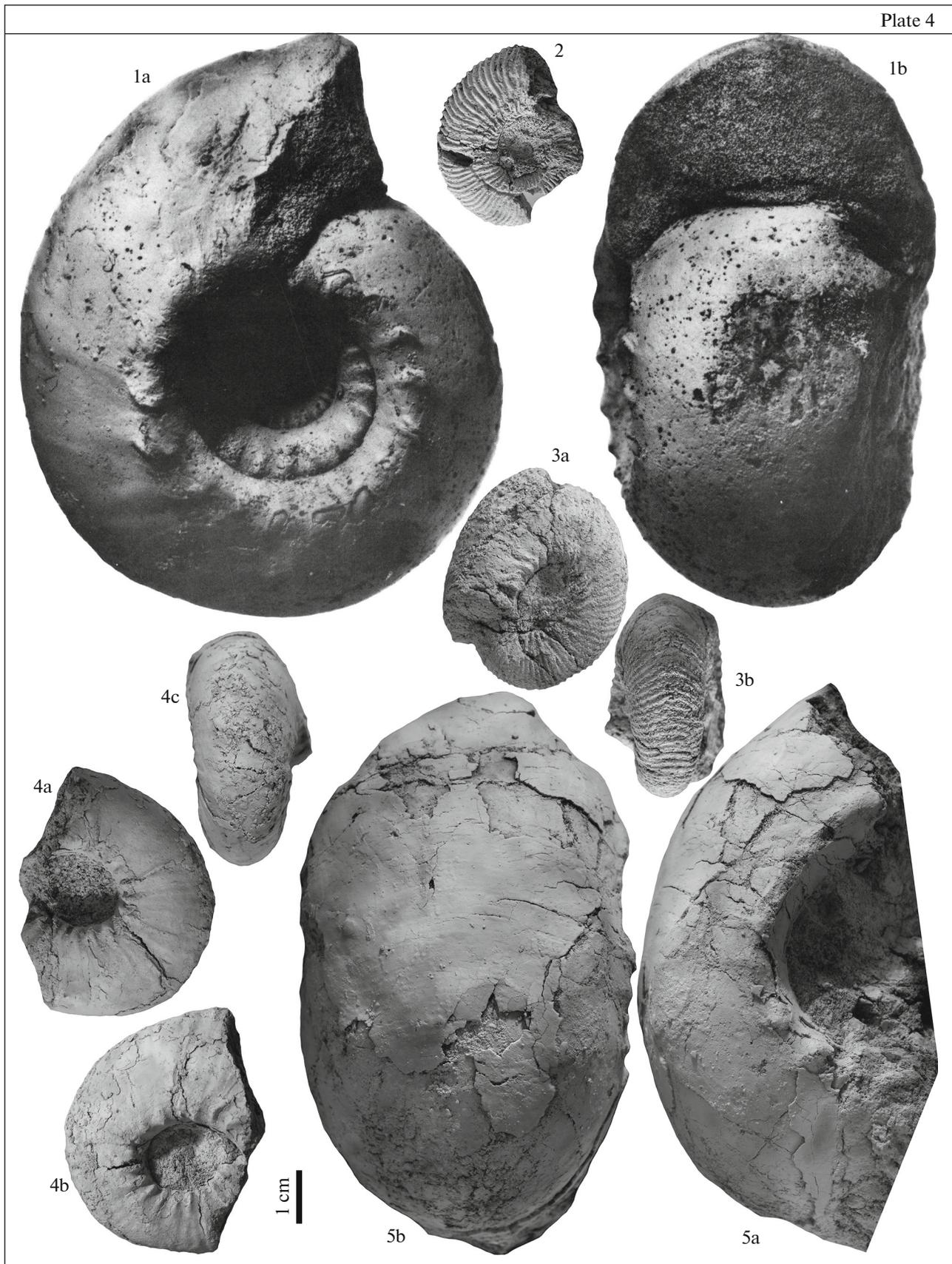
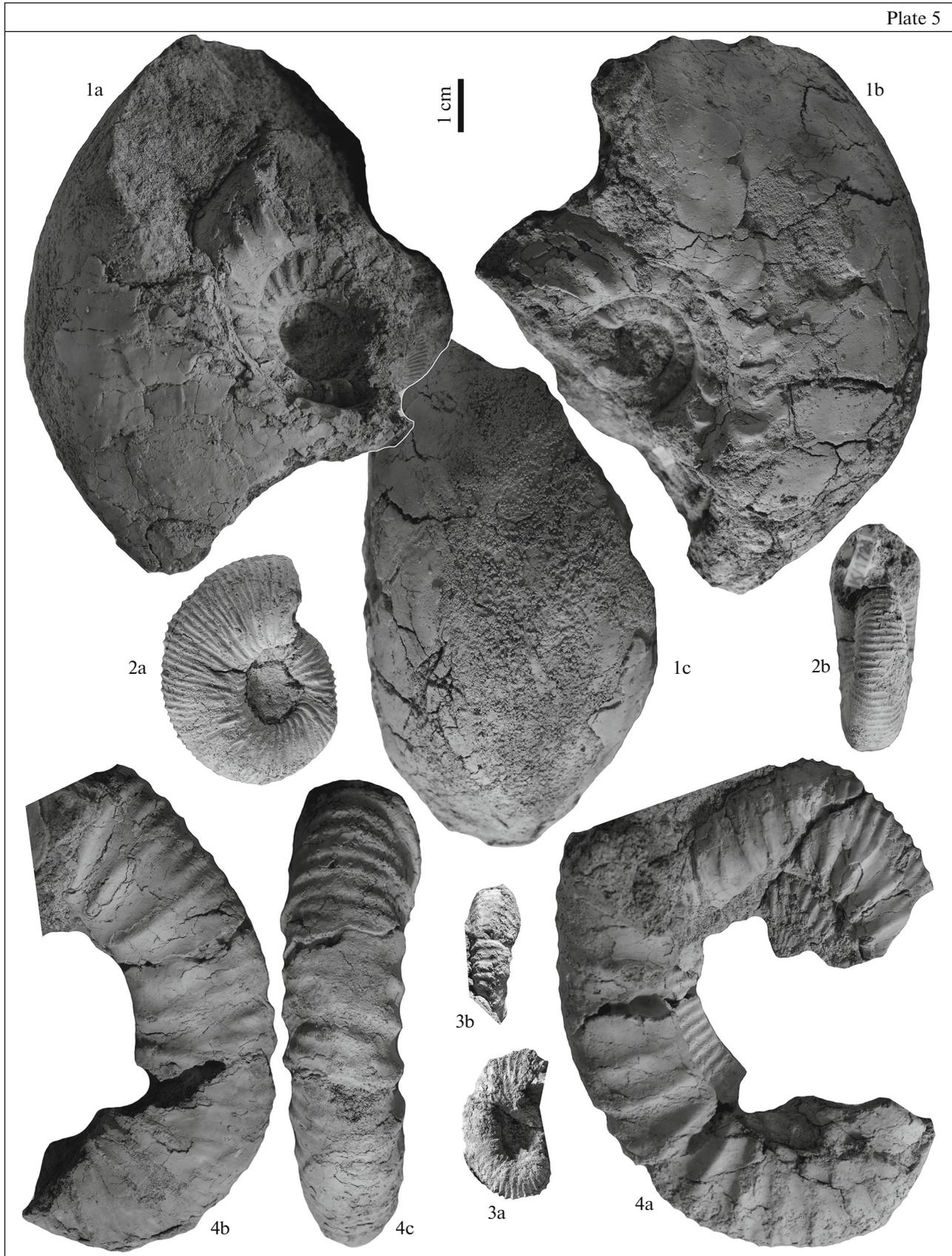


Plate 2

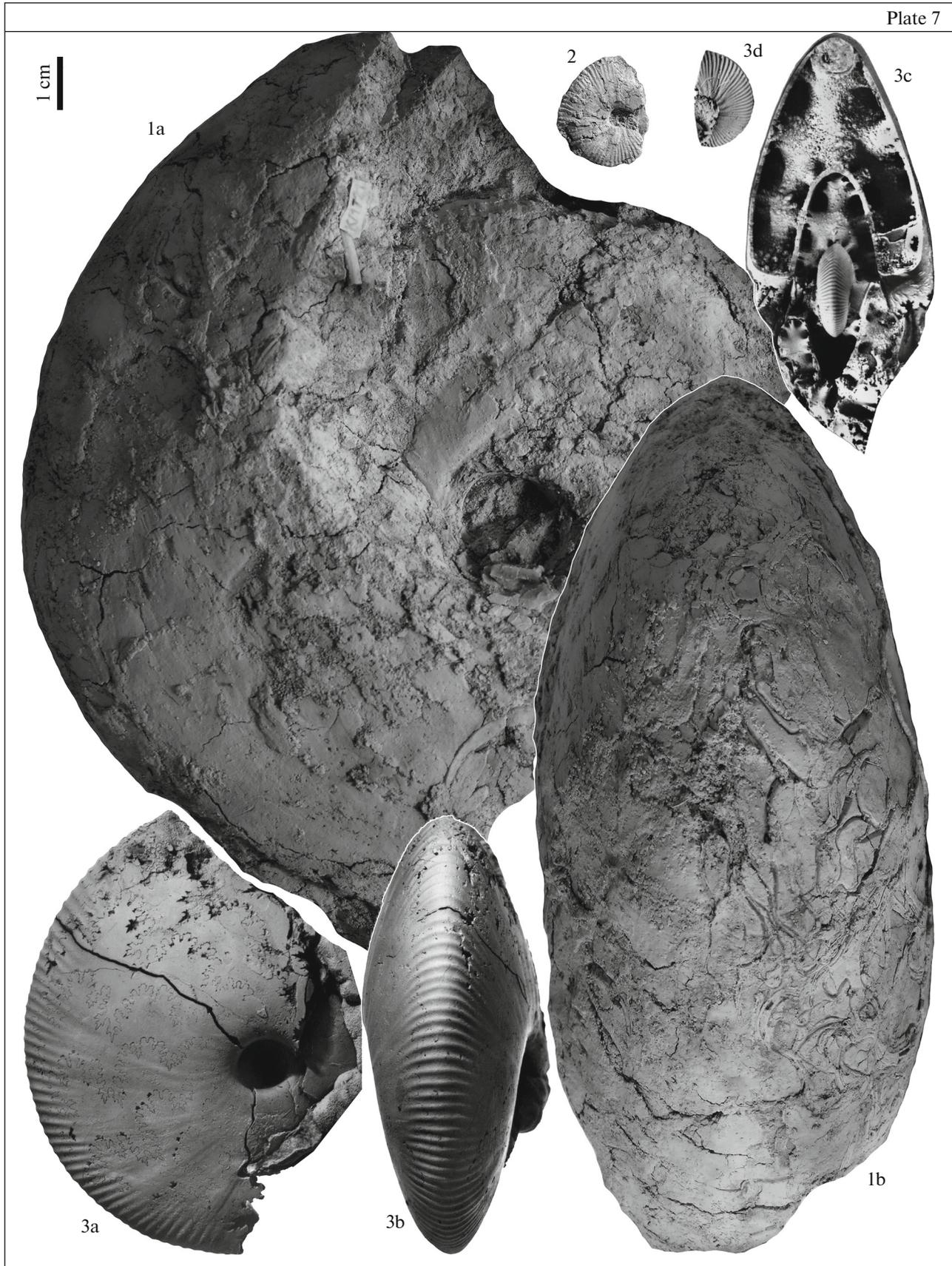


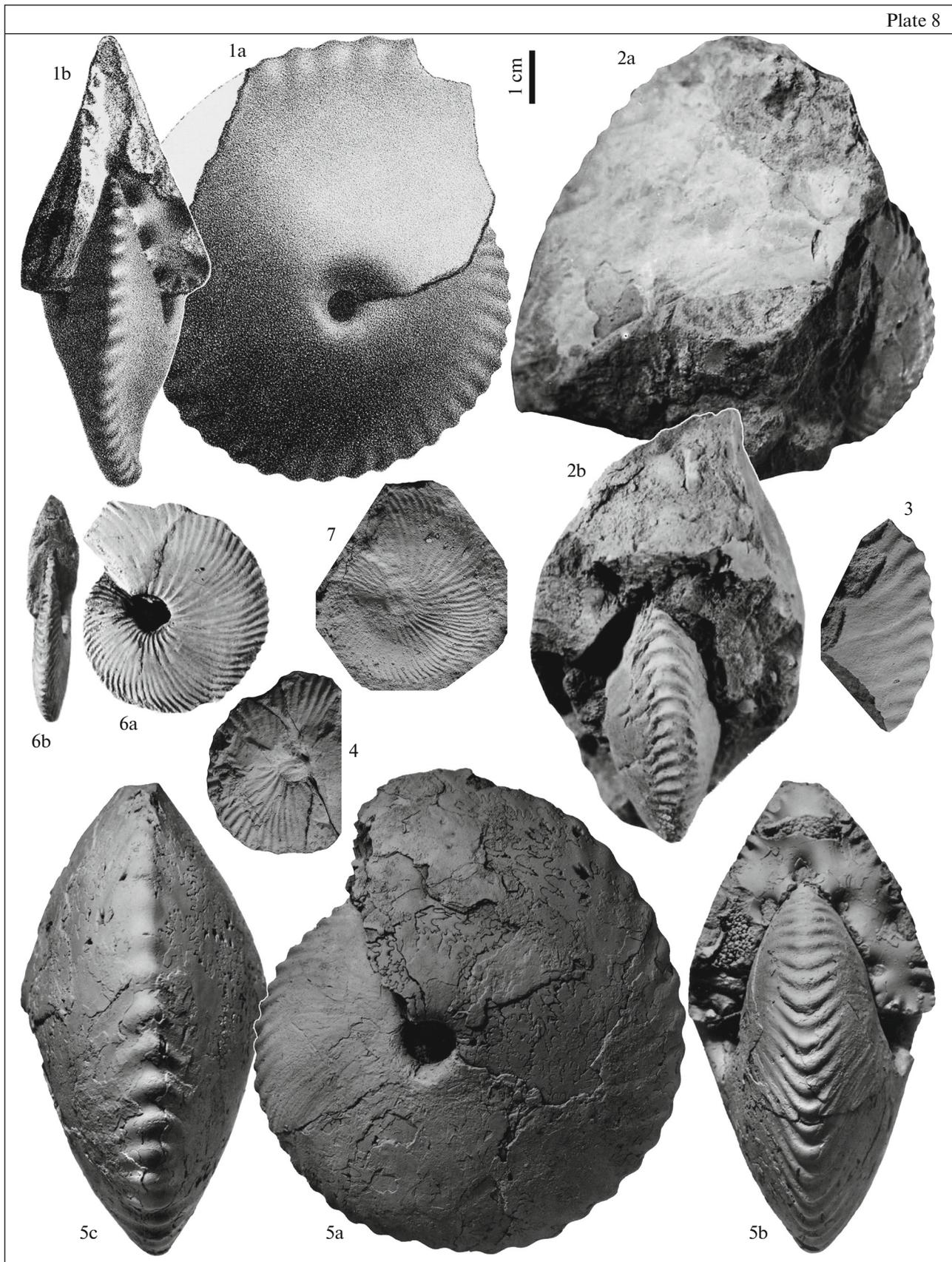


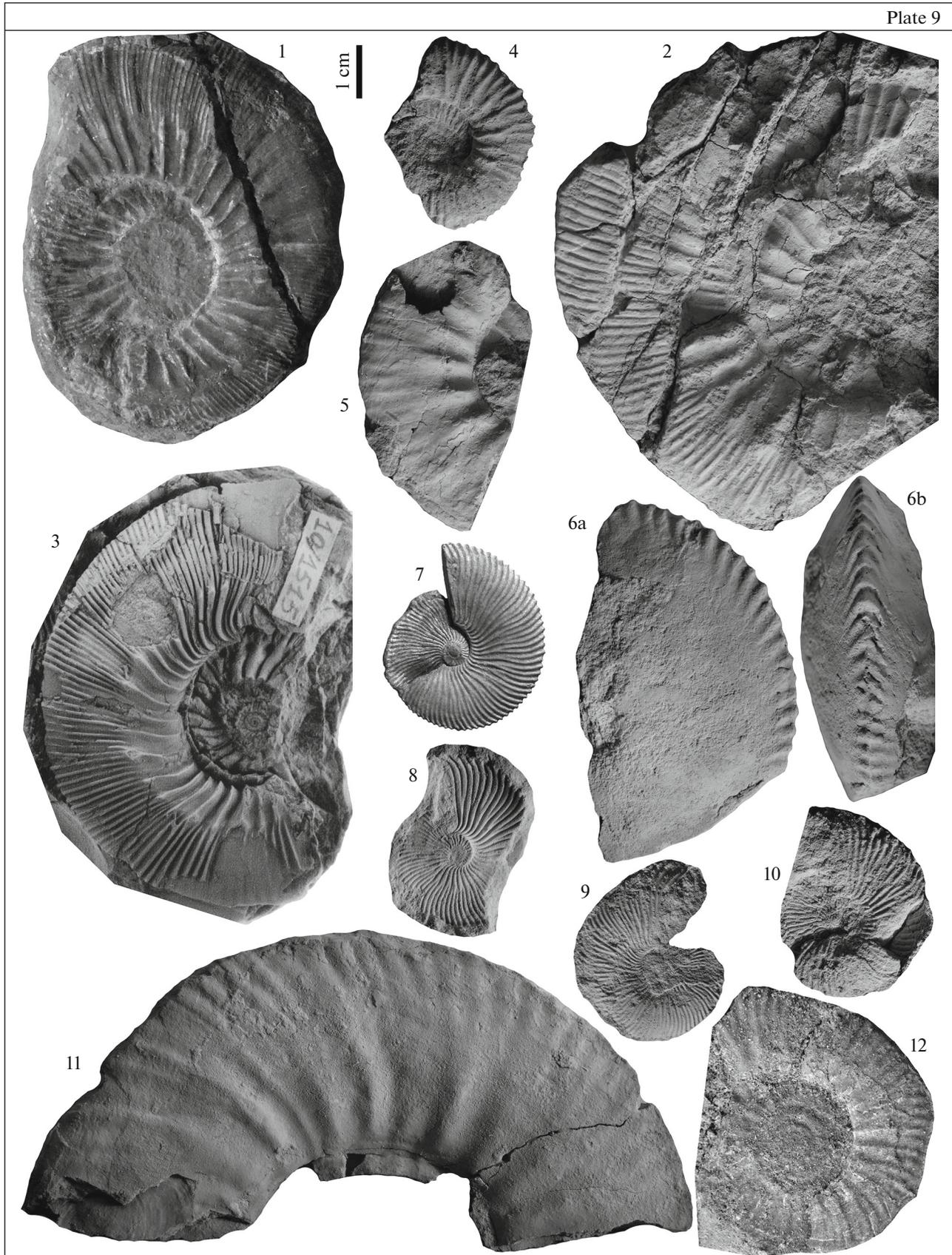


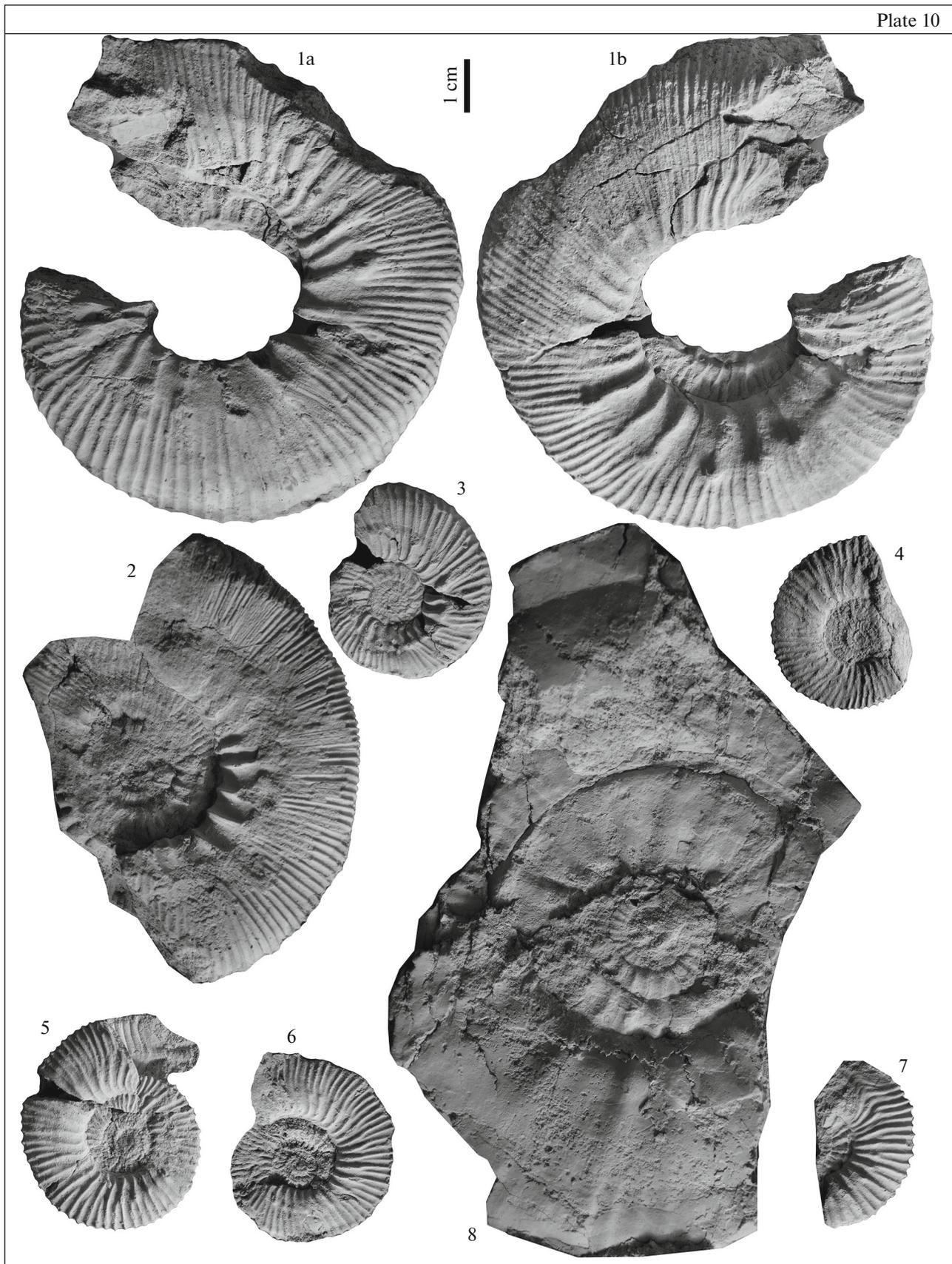




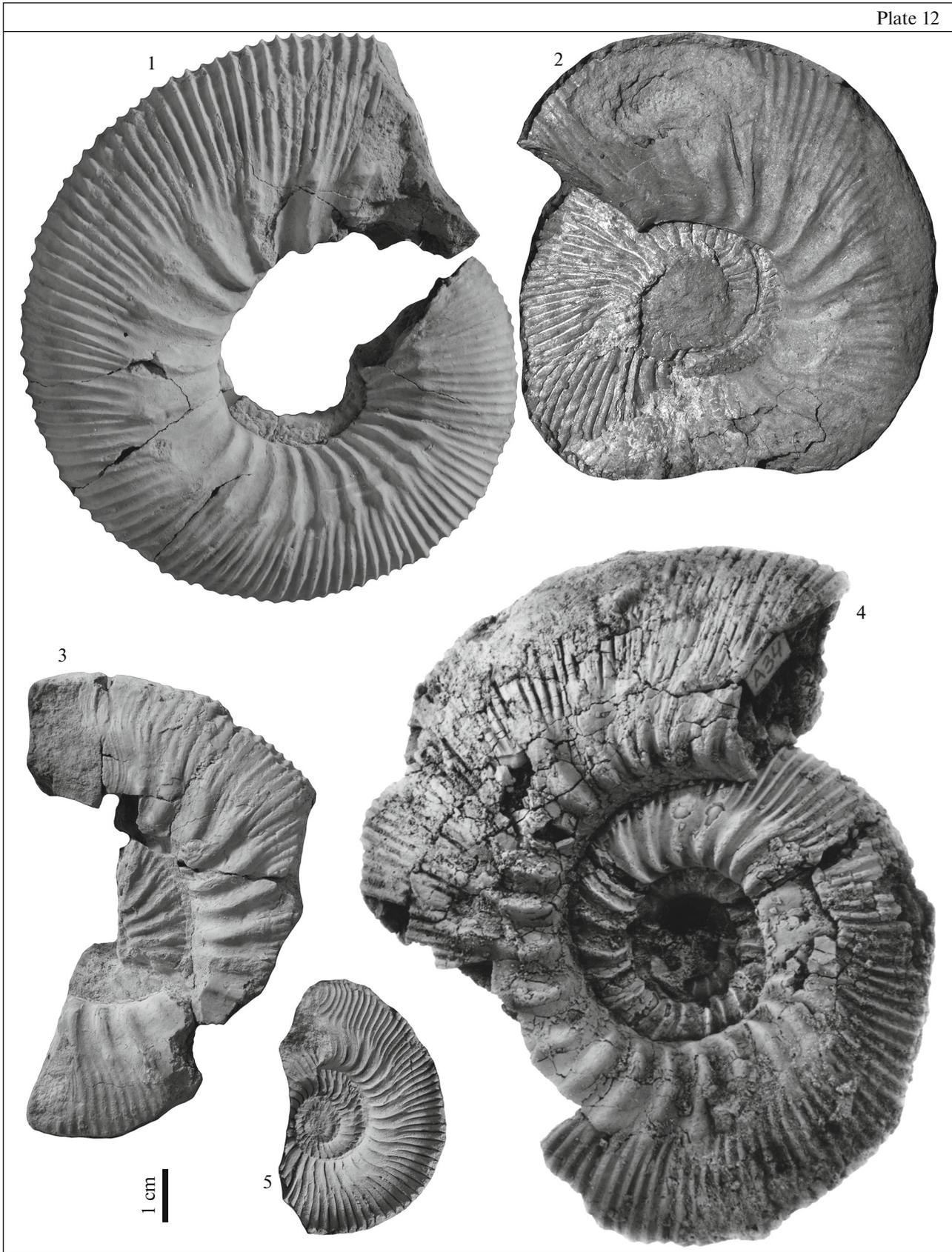


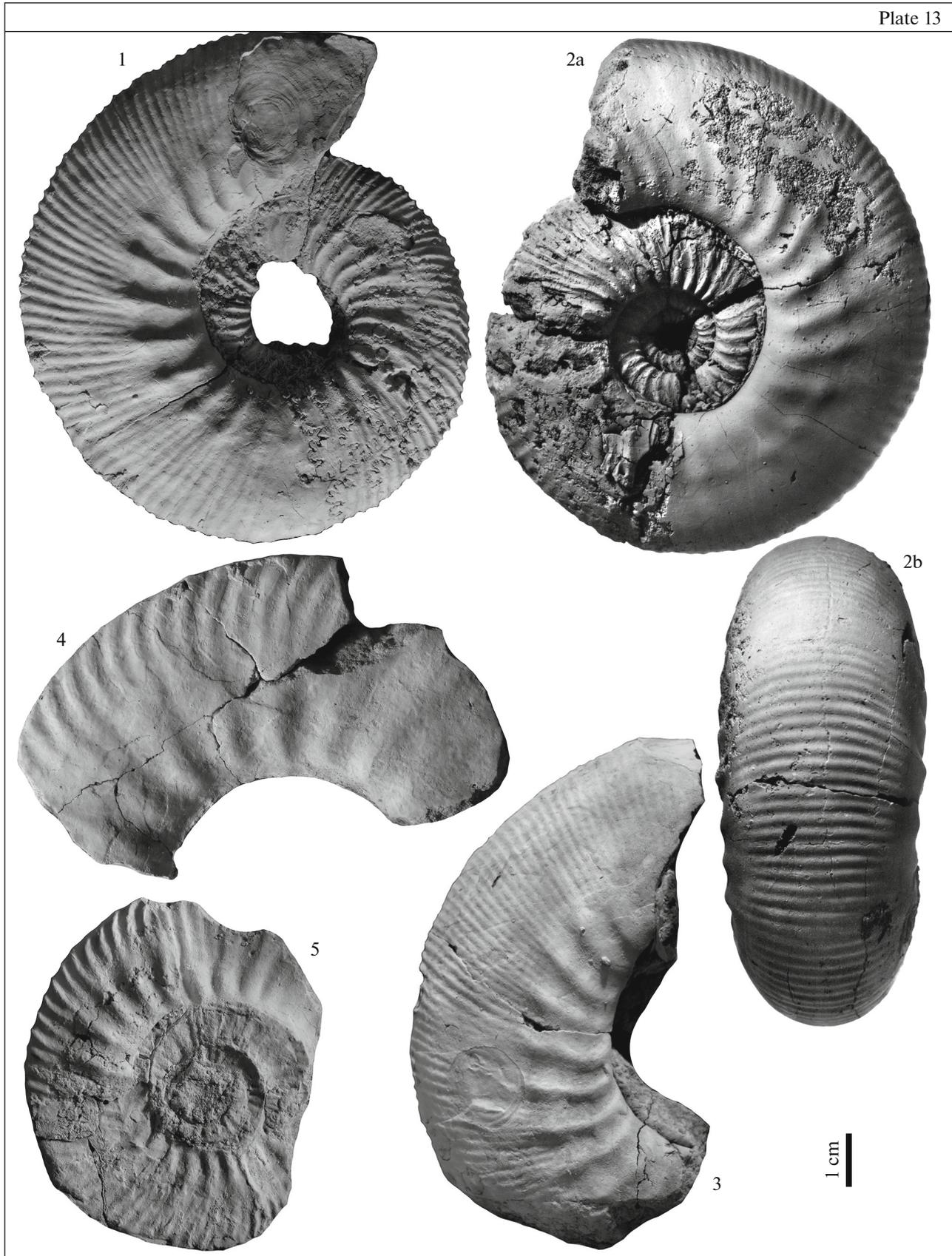




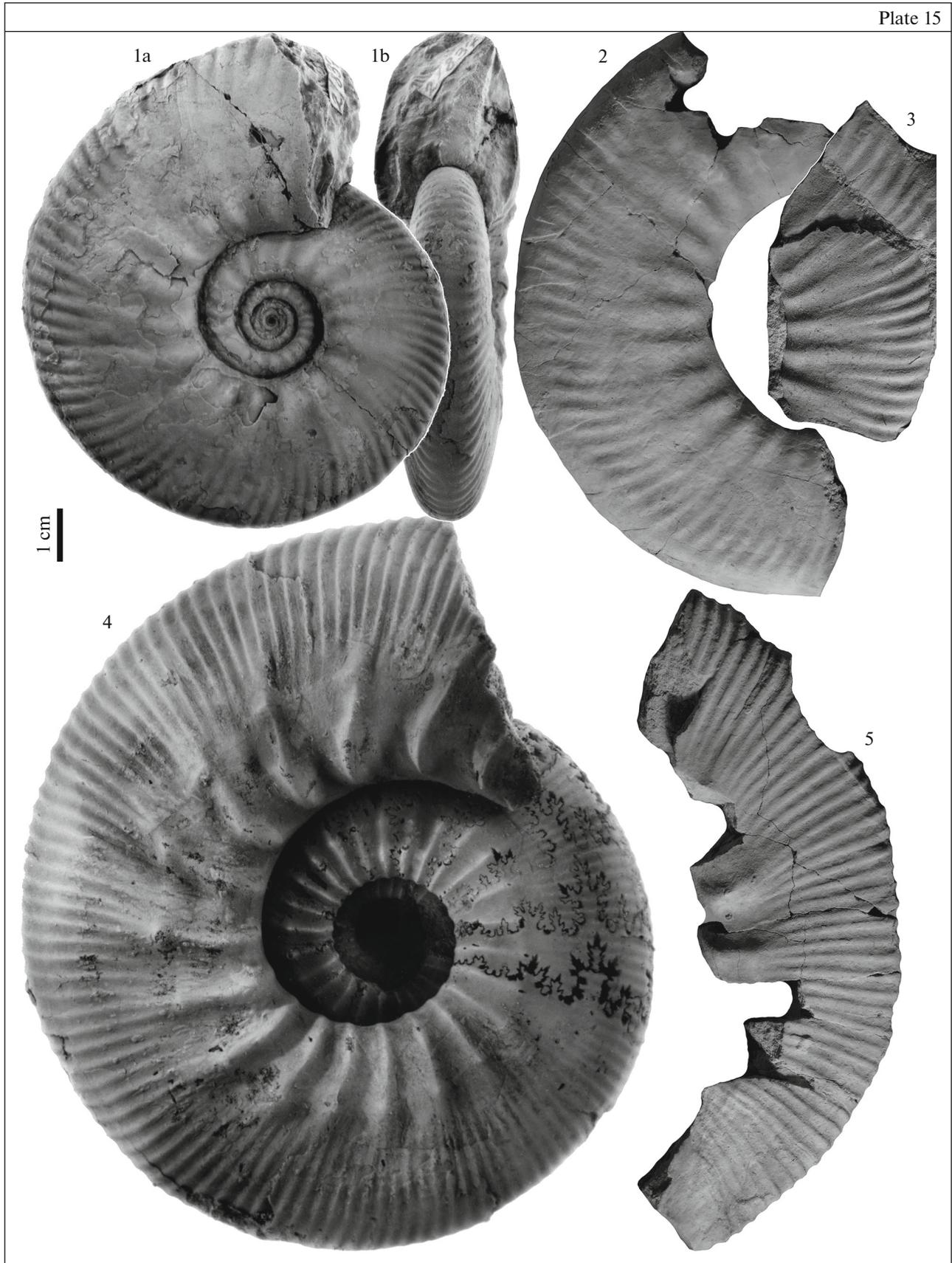


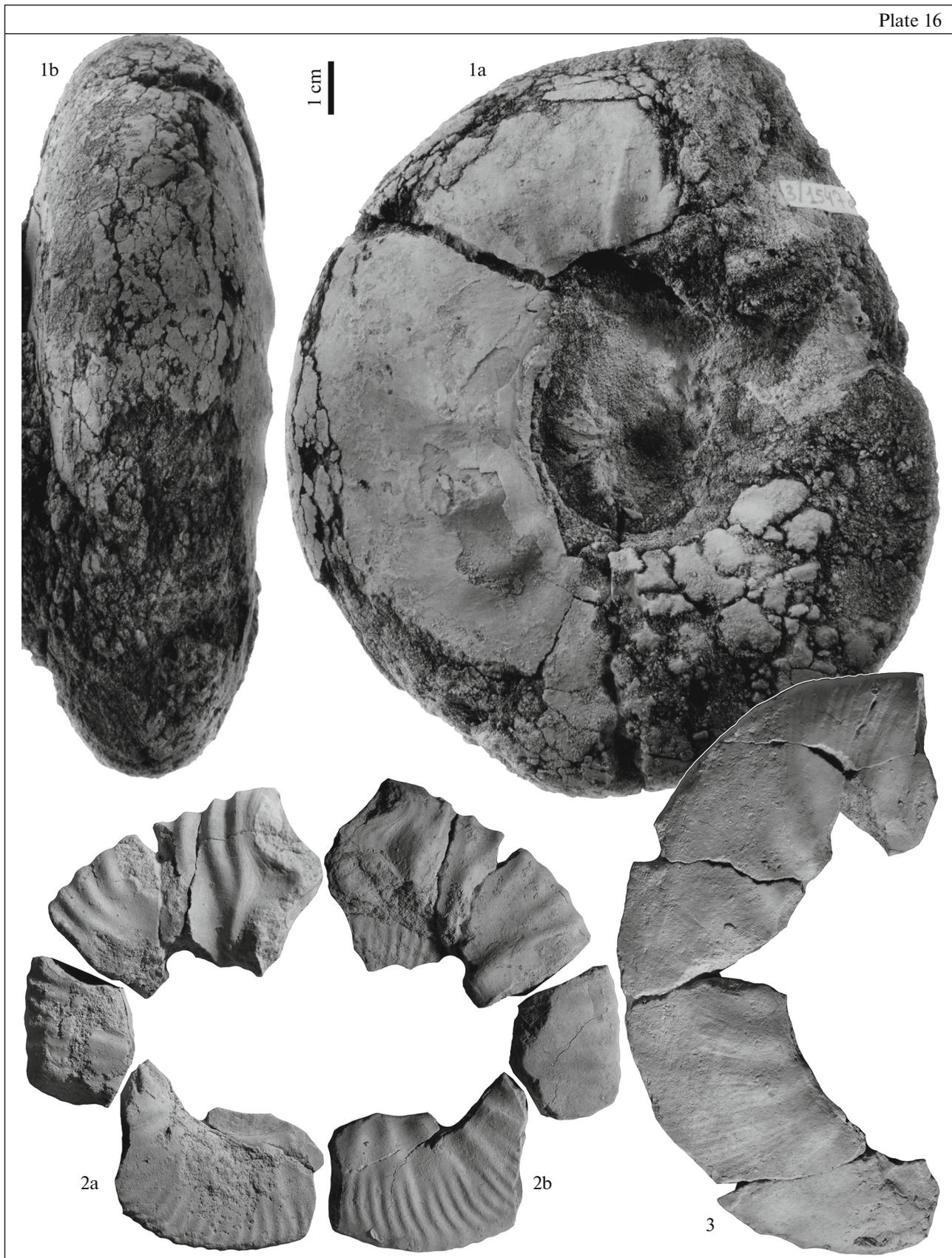








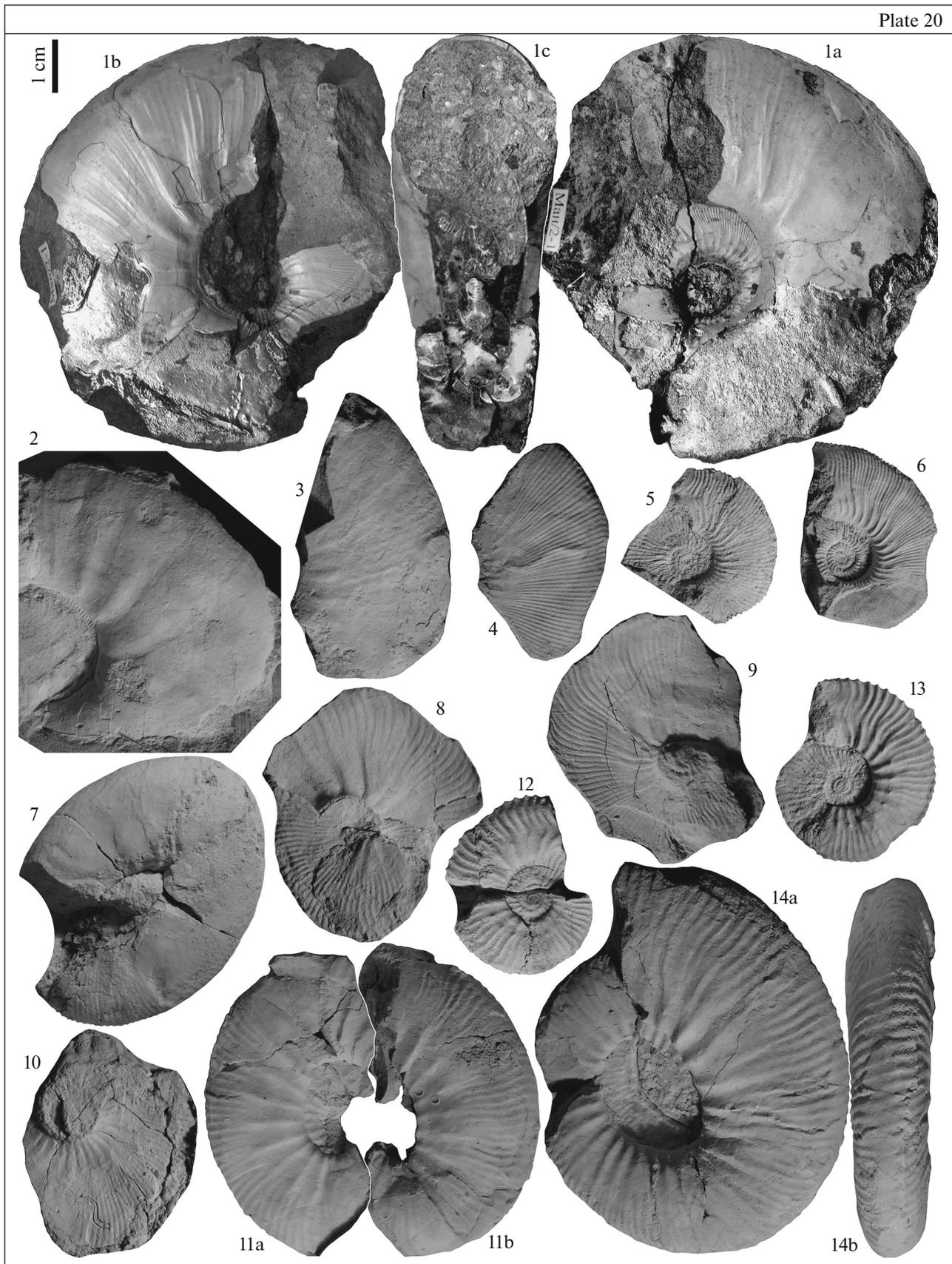


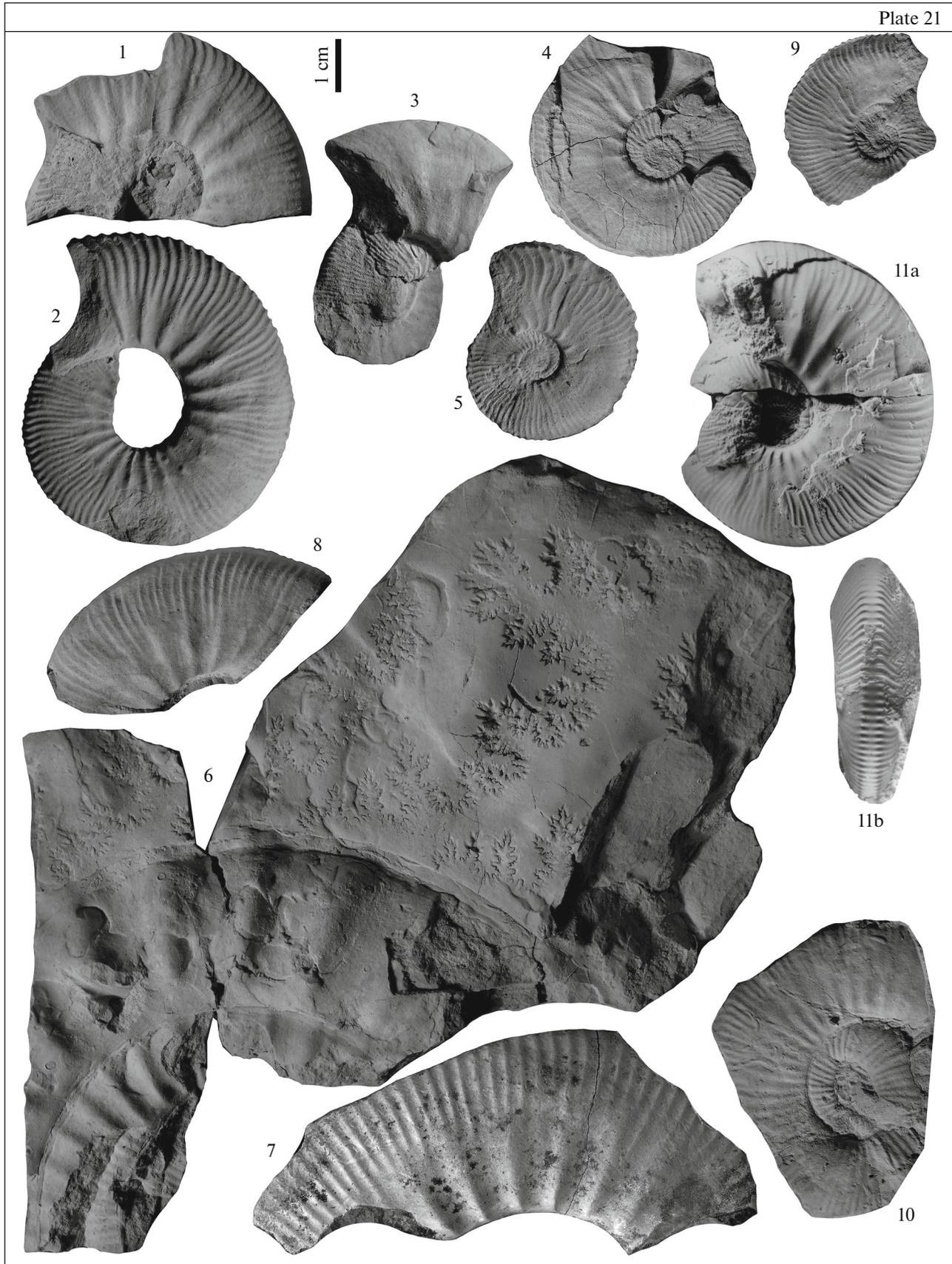












All figures are natural size. Most specimens collected at the Kanev dislocations area have been deformed. Most specimens have been whitened with ammonium chloride. Specimens marked as YSPU are stored in the collection of the Yaroslavl State Pedagogical University, NMNH—National Museum of Natural History at the National Academy of Sciences of Ukraine (Kiev), IGS—Institute of Geological Sciences of the National Academy of Sciences of Ukraine (Kiev). Localities of the Kanev dislocations area marked as GR-1, -2, -3, -4—Grigorovka-1, -2, -3, -4, KO—Kostyanetsky ravine, LU-1, -2—Lukovitsa-1, -2, MO—Monastyrek-2, TR—Trakhtemirov and neighborhood.

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Plate 1. (1a, 1b) *Paracadoceras elatmae* (Nikitin), NMNH 369/1065 (coll. of K.M. Feofilaktov), KO, Elatmae Zone, P. elatmae Biohorizon; (2a, 2b) *Paracadoceras elatmae* (Nikitin), YSPU K/1703, GR-1, bed 3, uppermost part, Elatmae Zone, P. elatmae Biohorizon; (3a, 3b) *Paracadoceras elatmae* (Nikitin), YSPU K/1710, GR-1, bed 3, near the top, Elatmae Zone, P. elatmae Biohorizon; (4) *Paracadoceras elatmae* (Nikitin), YSPU K/1758, KO, bed 2, 100 cm above the bottom, Elatmae Zone, P. elatmae Biohorizon; (5) “*Pseudocadoceras*” *mundum* (Sasonov), YSPU K/1762, KO, bed 2, 170 cm below the top, Elatmae Zone, P. elatmae Biohorizon; (6a, 6b) *Macrocephalites verus* Buckman, NMNH 369/1005 (coll. of K.M. Feofilaktov), KO, Elatmae Zone, P. elatmae Biohorizon; (7) *Macrocephalites* cf. *verus* Buckman, YSPU K/1760, KO, bed 2, 160 cm above the bottom, Elatmae Zone, P. elatmae Biohorizon; (8) *Macrocephalites multicosatus* (Paryshev), YSPU K/1761, KO, bed 2, 180 cm below the top, Elatmae Zone, P. elatmae Biohorizon; (9) *Homoeoplanulites*(?) ex gr. *furculus* (Neumayr), NMNH 369/995 (coll. of K.M. Feofilaktov), KO, probably Elatmae Zone (see Plate 2, fig. 8).

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Plate 2. (1a, 1b) *Macrocephalites volgensis* Gulyaev, NMNH 369/1015 (coll. of K.M. Feofilaktov), KO, Elatmae Zone, P. elatmae Biohorizon; (2) *Macrocephalites* sp., NMNH 369/530 (coll. of K.M. Feofilaktov), KO, Elatmae Zone, P. elatmae Biohorizon; (3) *Macrocephalites verus* Buckman, NMNH 369/630 (coll. of K.M. Feofilaktov), KO, Elatmae Zone, P. elatmae Biohorizon; (4a, 4b) *Macrocephalites verus* Buckman, NMNH 369/809 (coll. of K.M. Feofilaktov), KO, Elatmae Zone, P. elatmae Biohorizon; (5a, 5b) *Macrocephalites multicosatus* (Paryshev), YSPU K/1700, GR-1, bed 3, 60 cm below the top, Elatmae Zone, P. elatmae Biohorizon; (6) *Macrocephalites multicosatus* (Paryshev), YSPU K/1749, LU-2, bed 3 (=bed 3 of GR-1), 60 cm below the top, Elatmae Zone, P. elatmae Biohorizon; (7a, 7b) *Macrocephalites terebratus* (Phillips), NMNH 369/868 (coll. of K.M. Feofilaktov), KO, Elatmae Zone, P. elatmae Biohorizon; (8) *Homoeoplanulites*(?) ex gr. *furculus* (Neumayr), NMNH 369/995 (coll. of K.M. Feofilaktov), KO, probably Elatmae Zone (See Plate 1, fig. 9).

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Plate 3. (1a, 1b) *Macrocephalites multicosatus* (Paryshev) (specimen compressed), holotype IGS 1774/28 (Paryshev, 1977, p. 71, pl. I, figs. 1a, 1b), KO, Elatmae Zone, P. elatmae Biohorizon; (2) *Macrocephalites multicosatus* (Paryshev) (specimen compressed), paratype IGS 1774/27 (Paryshev, 1977, p. 71, pl. I, figs. 2a, 2b), Kanev district, Hmel'naya village, Klenovy Ravine (southern end of the Kanev dislocations), Elatmae Zone, P. elatmae Biohorizon; (3a, 3b) *Macrocephalites multicosatus* (Paryshev), plaster cast (see Mitta, 2009, pl. 7, figs. 3a, 3b) of the holotype of *Chamousetia menzeli* Mönnig (1995, S. 53–55, Taf. 9, figs. 1a–1c), Lower Saxony, Hildesheim, Hervey Zone, ?P. suevicum Biohorizon; (4a, 4b) *Macrocephalites multicosatus* (Paryshev), Geological Museum of the University of Copenhagen JHC-2277 (coll. of J.H. Callomon), East Greenland, Jameson Land, Juraely section, Apertum Zone, P. breve Biohorizon (Photos courtesy of Dr. P. Alsen, GEUS, Copenhagen); (5a–5d) *Macrocephalites multicosatus* (Paryshev), holotype of *M. prosekensis* Gulyaev (2001a, p. 78: nom. nov. pro *M.* ex gr. *jacquoti* in Gulyaev, 1999, p. 73, pl. I, figs. 1a–1e), Nizhny Novgorod oblast, Lyskovo district, quarry near Prosek village, Elatmae Zone, P. elatmae Biohorizon (see section in Rogov et al., 2012, fig. 3); (6) *Macrocephalites multicosatus* (Paryshev), NMNH 369/934 (coll. of K.M. Feofilaktov), KO, Elatmae Zone, P. elatmae Biohorizon; (7a, 7b) *Macrocephalites multicosatus* (Paryshev), YSPU 8/1403, previously figured as *M. prosekensis* (Gulyaev, 2007, pl. IV, figs. 4a, 4b), Komi Republic, Ust-Tzilma district, Pizhma R., Churkinskaya Stehlya section, Elatmae Zone, P. elatmae Biohorizon.

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Plate 4. (1a, 1b) *Paracadoceras vasily* Gulyaev, sp. nov., paratype CR-2102 (CF VNIGNI), figured by Mitta (2000, pl. 21, figs. 1a, 1b) as *Cadoceras tschernyschewi* Sokolov, Kostroma oblast, Makaryev district, Unzha R., near Popovo-Mikhalenino village, condensed sands of Elatmae, Subpatruus and lowermost Koenigi Zones (bed 3 in Mitta, 2000, p. 11); (2) “*Pseudocadoceras*” cf. aff. *mundum* (Sasonov), YSPU K/1732, GR-1, bed 4, Elatmae Zone, P. vasily Biohorizon; (3a, 3b) *Paracadoceras vasily* Gulyaev, sp. nov., paratype YSPU K/1727, GR-1, bed 4, Elatmae Zone, P. vasily Biohorizon; (4a–4c) *Paracadoceras vasily* Gulyaev, sp. nov., paratype YSPU K/1714, GR-1, bed 4, at the bottom, Elatmae Zone, P. vasily Biohorizon; (5a, 5b) *Paracadoceras vasily* Gulyaev, sp. nov., YSPU, paratype K/1719, GR-1, bed 4, at the bottom, Elatmae Zone, P. vasily Biohorizon.

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Plate 5. (1a–1c) *Paracadoceras vasily* Gulyaev, sp. nov., paratype YSPU K/1715, GR-1, bed 4, at the bottom, Elatmae Zone, P. vasily Biohorizon; (2a, 2b) *Gowericeras* cf. aff. *russienne* (Mitta), YSPU K/1724, GR-1, bed 4, lowermost part, Elatmae Zone, P. vasily Biohorizon; (3a, 3b) *Toricellites* cf. aff. *unzhensis* Mitta, YSPU K/1730, GR-1, bed 4, Elatmae Zone, P. vasily Biohorizon; (4a–4c) *Choffatia* ex gr. *recuperoi* (Gemellaro), YSPU K/1720, GR-1, bed 4, at the bottom, Elatmae Zone, P. vasily Biohorizon.

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Plate 6. (1a–1c) *Paracadoceras vasily* Gulyaev, sp. nov., holotype YSPU K/1729, GR-1, bed 4, middle part, Elatmae Zone, P. vasily Biohorizon; (2a, 2b) *Choffatia*(?) sp., YSPU K/1725, GR-1, bed 4, 5 cm above the bottom, Elatmae Zone, P. vasily Biohorizon; (3a–3c) *Homoeoplanulites* sp., YSPU K/1756, LU-2, bed 4 (=bed 4 of GR-1), Elatmae Zone, P. vasily Biohorizon; (4) *Parachoffatia* (?) sp., YSPU K/1731, GR-1, bed 4, Elatmae Zone, P. vasily Biohorizon.

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Plate 7. (1a, 1b) *Macrocephalites pavlowi* Smorodina, YSPU K/1721, GR-1, bed 4, at the bottom, Elatmae Zone, P. vasily Biohorizon; (2) *Macrocephalites pavlowi* Smorodina, YSPU K/1708, GR-1, bed 4, at the bottom, Elatmae Zone, P. vasily Biohorizon; (3a–3d) *Macrocephalites pavlowi* Smorodina, previously described in (Gulyaev, 1999, p. 73, pl. I, figs. 4a, 4b; pl. II, figs. 1a–1c), Nizhny Novgorod oblast, Lyskovo district, quarry near Prosek village, Subpatruus Zone, lower path of C.-ch. surensis Biohorizon (see section in Rogov et al., 2012, fig. 3).

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Plate 8. (1a, 1b) The original figure of *Amm. lamberti crobyloides* Quenstedt, 1887, Taf. 90, Fig. 19, lost (?) holotype, Southern Germany, Metzingen, Braunjura zeta; (2a, 2b) *Chamousettia saratovensis* Callomon et Wright, IGS 1774/24 (coll. of A.V. Paryshev), figured by Paryshev (1969, pl. VI, figs. 1a, 1b) as *Ch. chamousetti* (Orb.), KO, Subpatruus Zone, Ch. saratovensis/G. toricellii Biohorizon; (3) *Chamousettia saratovensis* Callomon et Wright, YSPU K/1681, MO, bed 7, 50 cm below the top, Subpatruus Zone, Ch. saratovensis/G. toricellii Biohorizon; (4) *Chamousettia saratovensis* Callomon et Wright, YSPU K/1685, MO, bed 9, 50 cm above the bottom, Subpatruus Zone, Ch. saratovensis/G. toricellii Biohorizon; (5a–5c) *Chamousettia saratovensis* Callomon et Wright, Paleontological Institute of the Russian Academy of Sciences (PIN RAS, Moscow) 4861/13 (coll. of P.G. Gerasimov), Kostroma oblast, Unzha R., approx. 4–5 km SSE of Kologriv, Subpatruus Zone, Ch. saratovensis Biohorizon; (6a, 6b) *Pseudocadoceras planum* (Paryshev) (specimen compressed), holotype IGS 1774/6 (Paryshev, 1977, pp. 72, 73, pl. II, figs. 1a, 1b, 5), TR, Zaguzovka Hill, Subpatruus Zone, Ch. saratovensis/G. toricellii Biohorizon; (7) *Pseudocadoceras planum* (Paryshev), YSPU K/1682, MO, bed 7, 20 cm below the top, Subpatruus Zone, Ch. saratovensis/G. toricellii Biohorizon.

p. 824

Plate 9. (1) *Gowericeras toricellii* (Oppel), NMNH 926/69 (coll. of V.V. Reznitchenko and K.A. Tsytovtich), TR, Subpatruus Zone, Ch. saratovensis/G. toricellii Biohorizon; (2) *Gowericeras toricellii* (Oppel), YSPU K/1743, GR-1, bed 8, 20 cm above the bottom, Subpatruus Zone, Ch. saratovensis/G. toricellii Biohorizon; (3) *Gowericeras toricellii* (Oppel), YSPU 10/1515, Kursk oblast, Mikhailovka mine near Zheleznogorsk, bed 2, lower part (see section in Tesakova et al., 2009), Subpatruus Zone, Ch. saratovensis/G. toricellii Biohorizon; (4) *Toricellites uhligi* (Parona et Bonarelli), YSPU K/1659, GR-2, lowermost part of the section, Subpatruus Zone, Ch. saratovensis/G. toricellii Biohorizon; (5) *Proplanulites* cf./aff. *koenigi* (Sowerby), YSPU K/1684-1, MO, bed 9, 50 cm above the bottom, Subpatruus Zone, Ch. saratovensis/G. toricellii Biohorizon; (6a, 6b) *Chamousettia chamousetti* (d'Orbigny), YSPU K/1674, GR-2, lower middle part of the section (=bed 10 of GR-1), Koenigi Zone, Gowerianum Subzone, G. metorchum Biohorizon; (7) *Pseudocadoceras boreale* Buckman, NMNH 1774/1 (coll. of A.V. Paryshev), holotype of *Quenstedticeras tsytovitchae* Paryshev (1968a, pp. 111, 112, figs. 1a, 1b), TR, Vyazki Hill, Koenigi Zone, Gowerianum Subzone, G. metorchum Biohorizon; (8) *Pseudocadoceras boreale* Buckman, YSPU K/1699, MO, bed 16, Koenigi Zone, Gowerianum Subzone, G. metorchum Biohorizon; (9) *Pseudocadoceras boreale* Buckman, YSPU K/1669, GR-2, lower middle part of the section (=bed 10 of GR-1), Koenigi Zone, Gowerianum Subzone, G. metorchum Biohorizon; (10) *Pseudocadoceras boreale* Buckman, YSPU K/1672, GR-2, lower middle part of the section (=bed 10 of GR-1), Koenigi Zone, Gowerianum Subzone, G. metorchum Biohorizon; (11) *Proplanulites koenigi* (Sowerby), YSPU K/1693, MO, bed 13, Koenigi Zone, Gowerianum Subzone, G. metorchum Biohorizon; (12) *Homoeoplanulites* (?) cf. *lobatus* (Buckman), field photo of uncollected specimen, MO, bed 13, Koenigi Zone, Gowerianum Subzone, K. metorchum Biohorizon.

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Plate 10. (1a, 1b) *Gowericeras metorchum* Buckman, YSPU K/1694, MO, bed 13, Koenigi Zone, Gowerianum Subzone, G. metorchum Biohorizon; (2) *Gowericeras metorchus* Buckman, YSPU K/1691, MO, bed 13, Koenigi Zone, Gowerianum Subzone, G. metorchum Biohorizon; (3) *Gowericeras metorchus* Buckman, YSPU K/1687, MO, bed 11, Koenigi Zone, Gowerianum Subzone, G. metorchum Biohorizon; (4) *Toricellites hexagonus* (Loewe), YSPU K/1678, GR-2, lower middle part of the section (=bed 10 of GR-1), Koenigi Zone, Gowerianum Subzone, G. metorchum Biohorizon; (5) *Toricellites hexagonus* (Loewe), YSPU K/1680, GR-2, lower middle part of the section (=bed 10 of GR-1), Koenigi Zone, Gowerianum Subzone, G. metorchum Biohorizon; (6) *Toricellites hexagonus* (Loewe), YSPU K/1697, MO, bed 15, Koenigi Zone, Gowerianum Subzone, K. metorchum Biohorizon; (7) *Toricellites hexagonus* (Loewe), YSPU K/1688, MO, bed 11, 20 cm above the bottom, Koenigi Zone, Gowerianum Subzone, G. metorchum Biohorizon; (8) *Proplanulites koenigi* (Sowerby), YSPU K/1689, MO, bed 12, Koenigi Zone, Gowerianum Subzone, G. metorchum Biohorizon.

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Plate 11. (1) *Gowericeras gowerianum* (Sowerby), YSPU K/1655, GR-3, bed 17, 10 cm above the bottom, Koenigi Zone, Gowerianum Subzone, G. gowerianum Biohorizon; (2a, 2b) *Gowericeras gowerianum* (Sowerby), YSPU K/1653, GR-3, bed 13, 10 cm above the bottom, Koenigi Zone, Gowerianum Subzone, G. gowerianum Biohorizon; (3) *Gowericeras gowerianum* (Sowerby), YSPU K/1650, GR-3, bed 10, 5 cm below the top, Koenigi Zone, Gowerianum Subzone, G. gowerianum Biohorizon; (4a, 4b) *Gowericeras gowerianum* (Sowerby), YSPU 3/1492, Kostroma oblast, Kologriv district, Unzha R., near Burdovo village, bed 6, uppermost part (Fig. 14), Koenigi Zone, Gowerianum Subzone, G. gowerianum Biohorizon; (5) *Toricellites approximatus* Buckman, NMNH 926/72 (coll. of V.V. Reznitchenko and K.A. Tsytovtich), TR, Koenigi Zone, Gowerianum Subzone, G. gowerianum Biohorizon; (6) *Toricellites approximatus* Buckman, NMNH 926/76 (coll. of V.V. Reznitchenko and K.A. Tsytovtich), TR, Koenigi Zone, Gowerianum Subzone, G. gowerianum Biohorizon; (7) *Proplanulites capistratus* Buckman, YSPU K/1647, GR-3, bed 5, 20 cm above the bottom, Koenigi Zone, Gowerianum Subzone, G. gowerianum Biohorizon.

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Plate 12. (1) *Gowericeras indigestum* (Buckman), YSPU K/1567, GR-4, bed 4, Koenigi Zone, Curtilobum Subzone, G. indigestum Biohorizon; (2) *Gowericeras indigestum* (Buckman), field photo of uncollected specimen, LU-1, from beds below the water level, Koenigi Zone, Curtilobum Subzone, G. indigestum Biohorizon; (3) *Gowericeras indigestum* (Buckman), YSPU K/1564, GR-4, bed 3, 5 cm below the top, Koenigi Zone, Curtilobum Subzone, G. indigestum Biohorizon; (4) *Gowericeras indigestum* (Buckman), YSPU A34, Nizhny Novgorod oblast, Lyskovo district, quarry near Prosek village, bed 4, lower part, Koenigi Zone, Curtilobum Subzone, G. indigestum Biohorizon (see section in Rogov et al., 2012, fig. 3); (5) *Toricellites lahuseni* (Parona et Bonarelli), YSPU K/1660, GR-2, upper part of the section (same bed as that of specimens in Plate 13, figs. 1, 5), Koenigi Zone, Curtilobum Subzone, G. indigestum Biohorizon.

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Plate 13. (1) *Gowericeras indigestum* (Buckman), YSPU K/1664, GR-2, upper part of the section (same bed as that of specimens in Plate 12, fig. 5 and Plate 13, fig. 5), Koenigi Zone, Curtilobum Subzone, G. indigestum Biohorizon; (2a, 2b) *Gowericeras indigestum* (Buckman), YSPU A35, previously figured as *K. (G.) densicostatus* Tintant (Gulyaev, 2001a, pl. V, figs. 2a, 2b [$\times 0.7$]), Nizhny Novgorod oblast, Lyskovo district, quarry near Prosek village, bed 4, lower part, Koenigi Zone, Curtilobum Subzone, G. indigestum Biohorizon (see section in Rogov et al., 2012, fig. 3); (3) *Gowericeras indigestum* (Buckman), YSPU K/1569, GR-4, bed 4, near the top, Koenigi Zone, Curtilobum Subzone, G. indigestum Biohorizon; (4) *Proplanulites* ex gr. *ferruginosus* Buckman (*P. opimus* Buckman, morphotype), YSPU K/1565, GR-4, bed 4, Koenigi Zone, Curtilobum Subzone, G. indigestum Biohorizon; (5) *Proplanulites excentricus* Buckman, YSPU K/1665-1, GR-2, upper part of the section (same bed as that of specimens in Plate 12, fig. 5 and Plate 13, fig. 1), Koenigi Zone, Curtilobum Subzone, G. indigestum Biohorizon.

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Plate 14. (1a, 1b) *Gowericeras curtilobum* (Buckman), YSPU 3/1108, Kostroma oblast, Kologriv district, Unzha R., near Akatovo village (4 km NNW of Ileshevo village), sand similar to the lowermost part of the bed 2 in Ileshevo section (Fig. 14), Koenigi Zone, Curtilobum Subzone, G. curtilobum Biohorizon; (2a, 2b) *Gowericeras curtilobum* (Buckman), YSPU K/1572, GR-4, bed 5, Koenigi Zone, Curtilobum Subzone, G. curtilobum Biohorizon; (3) *Gowericeras curtilobum* (Buckman), YSPU K/1578-1, GR-4, bed 9, Koenigi Zone, Curtilobum Subzone, G. curtilobum Biohorizon; (4) *Toricellites curticornutus* Buckman, YSPU K/1666, GR-2, uppermost part of the section, Koenigi Zone, Curtilobum Subzone, G. curtilobum Biohorizon; (5) *Toricellites curticornutus* Buckman, YSPU K/1574, GR-4, bed 9, Koenigi Zone, Curtilobum Subzone, G. curtilobum Biohorizon; (6) *Toricellites curticornutus* Buckman, YSPU K/1575, GR-4, bed 9, Koenigi Zone, Curtilobum Subzone, G. curtilobum Biohorizon; (7) *Toricellites curticornutus* Buckman, YSPU K/1579, LU-1, bed 0, near the top, Koenigi Zone, Curtilobum Subzone, G. curtilobum Biohorizon.

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Plate 15. (1a, 1b) *Proplanulites ferruginosus* Buckman, YSPU 2/834, Nizhny Novgorod oblast, Lyskovo district, outcrop near Isady village, bed 4, middle part, Koenigi Zone, Curtilobum Subzone, G. curtilobum Biohorizon (see section in Rogov et al., 2012, fig. 3); (2) *Proplanulites ferruginosus* Buckman, YSPU K/1570, GR-4, bed 5, Koenigi Zone, Curtilobum Subzone, G. curtilobum Biohorizon; (3) *Proplanulites ferruginosus* Buckman, YSPU K/1576, GR-4, bed 9, Koenigi Zone, Curtilobum Subzone, G. curtilobum Biohorizon; (4) *Gowericeras crucifer* (Buckman), YSPU 3/613, Kostroma oblast, Kologriv district, Unzha R., near Burdovo village, bed 7, 0.4–0.9 m above the bottom (Fig. 14), Koenigi Zone, Curtilobum Subzone, G. crucifer Biohorizon; (5) *Gowericeras crucifer* (Buckman), YSPU K/1586, LU-1, bed 7, 20 cm above the bottom, Koenigi Zone, Curtilobum Subzone, G. crucifer Biohorizon.

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Plate 16. (1a, 1b) *Gowericeras galilaeii* (Oppel), YSPU 3/1547, Kostroma oblast, Kologriv district, ravine near Ileshevo village, bed 2, 1.5–1.7 m above the bottom (Fig. 14), Koenigi Zone, Galilaeii Subzone, G. galilaeii Biohorizon; (2a, 2b) *Proplanulites* ex gr. *petrosus* Buckman, YSPU K/1587, LU-1, bed 9, Koenigi Zone, Galilaeii Subzone, G. galilaeii (s.l.) Biohorizon; (3) *Gowericeras galilaeii* (Oppel) (later morphotype), YSPU K/1588, LU-1, bed 11, 10 cm above the bottom, Koenigi Zone, Galilaeii Subzone, G. galilaeii (s.l.) Biohorizon.

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Plate 17. (1a, 1b) *Sigaloceras khvalynicum* Repin et Rashwan, YSPU K/1589, LU-1, bed 11, 30 cm above the bottom, Calloviense Zone and Subzone, S. khvalynicum Biohorizon; (2) *Sigaloceras khvalynicum* Repin et Rashwan, YSPU K/1591, LU-1, bed 11, 30–40 cm above the bottom, Calloviense Zone and Subzone, S. khvalynicum Biohorizon; (3a, 3b) *Sigaloceras khvalynicum* Repin et Rashwan, YSPU K/1590, LU-1, bed 11, 30–40 cm above the bottom, Calloviense Zone and Subzone, S. khvalynicum Biohorizon.

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Plate 18. (1a, 1b) *Sigaloceras fundator* Gulyaev, sp. nov., holotype YSPU A/53, previously figured in (Gulyaev, 2001a, pl. V, figs. 4a, 4b [$\times 0.7$]), Nizhny Novgorod oblast, Lyskovo district, quarry near Prosek village, bed 4, uppermost part, Calloviense Zone and Subzone, S. fundator Biohorizon (see section in Rogov et al., 2012, fig. 3); (2a, 2b) *Sigaloceras calloviense* (Sowerby), YSPU 2/1764, Nizhny Novgorod oblast, Lyskovo district, quarry near Prosek village, bed 4, near the top, Calloviense Zone and Subzone, S. calloviense Biohorizon (see section in Rogov et al., 2012, fig. 3) (specimen kindly provided by collector M. Zamoshnikov, Nizhny Novgorod); (3) *Catasigaloceras pagei* (Mitta) (fragment of the adult body chamber), YSPU 13/1766a, quarry to the north of Saratov, near TPS-5, bed 8a, concretions at the bottom (Fig. 13), Calloviense Zone, Enodatium Subzone, C. pagei Biohorizon.

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Plate 19. (1a, 1b) *Sigaloceras fundator* Gulyaev, sp. nov. (finely ribbed smoothed variety), paratype YSPU 3/1548, Kostroma oblast, Unzha R., to the north of Makaryev, bed 1, 20 cm below the top [in the unpublished field description of the North Makaryev section by Gulyaev (2000) (=bed 1, ~5–10 cm below the top according to Kiselev, 2001, p. 10, fig. 2)], Calloviense Zone and Subzone, S. fundator Biohorizon; (2a, 2b) *Sigaloceras fundator* Gulyaev, sp. nov. (coarsely ribbed inflated variety), paratype YSPU 3/1550, Kostroma oblast, Unzha R., to the north of Makaryev, bed 1, 18 cm below the top [in the unpublished field description of the North Makaryev section by Gulyaev (2000) (=bed 1, ~3–8 cm below the top according to Kiselev, 2001, p. 10, fig. 2)], Calloviense Zone and Subzone, S. fundator Biohorizon.

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Plate 20. (1a–1c) *Sigaloceras kiselevi* Gulyaev, sp. nov., holotype YSPU Man/2-1 (coll. of D.N. Kiselev), Kostroma oblast, Unzha R., near Manturovo, condensed beds of Galilaei and Calloviense subzones (bed 3 in Mitta, 2000, pp. 12, 13); (2) *Sigaloceras kiselevi* Gulyaev, sp. nov., paratype YSPU K/1595, LU-1, bed 17, 25 cm above the bottom, Calloviense Zone and Subzone, S. kiselevi Biohorizon; (3) *Sigaloceras kiselevi* Gulyaev, sp. nov., paratype YSPU K/1592, LU-1, bed 15, Calloviense Zone and Subzone, S. kiselevi Biohorizon; (4) *Sigaloceras kiselevi* Gulyaev, sp. nov., paratype YSPU K/1594, LU-1, bed 16, Calloviense Zone and Subzone, S. kiselevi Biohorizon; (5) *Gulielmina aplanata* (Tsytovitch), YSPU K/1599, LU-1, bed 17, 20 cm above the bottom, Calloviense Zone and Subzone, S. kiselevi Biohorizon; (6) *Gulielmina aplanata* (Tsytovitch), YSPU K/1597, LU-1, bed 17, 10 cm above the bottom, Calloviense Zone and Subzone, S. kiselevi Biohorizon; (7) *Catasigaloceras enodatum planicerclus* Buckman, YSPU K/1603, LU-1, bed 21, 10 cm above the bottom, Calloviense Zone, Enodatum Subzone, C. enodatum planicerclus Biohorizon; (8) *Catasigaloceras enodatum planicerclus* Buckman, YSPU K/1615-1, LU-1, bed 26, Calloviense Zone, Enodatum Subzone, C. enodatum planicerclus Biohorizon; (9) *Catasigaloceras enodatum planicerclus* Buckman, YSPU K/1614, LU-1, bed 23, Calloviense Zone, Enodatum Subzone, C. enodatum planicerclus Biohorizon; (10) *Catasigaloceras enodatum planicerclus* Buckman, YSPU K/1601, LU-1, bed 20, Calloviense Zone, Enodatum Subzone, C. enodatum planicerclus Biohorizon; (11a, 11b) *Catasigaloceras enodatum planicerclus* Buckman, YSPU K/1620, LU-1, bed 27, Calloviense Zone, Enodatum Subzone, C. enodatum planicerclus Biohorizon; (12) *Gulielmiceras distans* (Tintant), YSPU K/1612, LU-1, bed 22, 10 cm above the bottom, Calloviense Zone, Enodatum Subzone, C. enodatum planicerclus Biohorizon; (13) *Gulielmiceras distans* (Tintant), YSPU K/1606, LU-1, bed 22, 20 cm above the bottom, Calloviense Zone, Enodatum Subzone, C. enodatum planicerclus Biohorizon; (14a, 14b) *Anaplanulites difficilis* Buckman, YSPU K/1617, LU-1, bed 27, Calloviense Zone, Enodatum Subzone, C. enodatum planicerclus Biohorizon.

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Plate 21. (1) *Catasigaloceras enodatum enodatum* (Nikitin), YSPU K/1629, LU-1, bed 30, Calloviense Zone, Enodatum Subzone, C. enodatum enodatum Biohorizon; (2) *Catasigaloceras enodatum enodatum* (Nikitin) (extremely coarsely ribbed inflated evolute variety), YSPU K/1644, LU-1, scree of beds 29–30, Calloviense Zone, Enodatum Subzone, C. enodatum enodatum Biohorizon; (3) *Catasigaloceras enodatum enodatum* (Nikitin) (typical morphotype), YSPU K/1639-1, LU-1, bed 29, Calloviense Zone, Enodatum Subzone, C. enodatum enodatum Biohorizon; (4) *Gulielmiceras anterior* (Brinkmann), YSPU K/1625, LU-1, bed 29, 10 cm below the top, Calloviense Zone, Enodatum Subzone, C. enodatum enodatum Biohorizon; (5) *Gulielmiceras anterior* (Brinkmann), YSPU K/1624, LU-1, bed 29, Calloviense Zone, Enodatum Subzone, C. enodatum enodatum Biohorizon; (6) *Choffatia vischniakoffi* (Teisseyre), YSPU K/1630-1, LU-1, bed 30, Calloviense Zone, Enodatum Subzone, C. enodatum enodatum Biohorizon; (7) *Indosphinctes mutatus* (Trautschold), field photo of uncollected specimen, LU-1, scree of beds 29–30, Calloviense Zone, Enodatum Subzone, C. enodatum enodatum Biohorizon; (8) *Catasigaloceras enodatum aeeta* (Kiselev), YSPU K/1632, LU-1, bed 31, 5 cm above the bottom, Calloviense Zone, Enodatum Subzone, C. enodatum aeeta Biohorizon; (9) *Gulielmiceras anterior* (Brinkmann), YSPU K/1634, LU-1, bed 31, Calloviense Zone, Enodatum Subzone, C. enodatum aeeta Biohorizon; (10) *Anaplanulites submutatus* (Nikitin), YSPU K/1631, LU-1, bed 31, Calloviense Zone, Enodatum Subzone, C. enodatum aeeta Biohorizon; (11a, 11b) *Catasigaloceras enodatum aeeta* (Kiselev), paratype YSPU E/M-11 (Kiselev, 2001, pp. 30, 31, pl. 5, figs. 6–7), Ryazan oblast, Oka R., near Elatma, Calloviense Zone, Enodatum Subzone, C. enodatum aeeta Biohorizon.

basin was a “pot” for neoendemic evolution of various ammonite groups, which primarily migrated from the Arctic, West European, and West Tethyan biochorems. Here, under conditions of oligotaxonic undersaturation of potential ecological space and low interspecies competition amidst an abundance of resources, migrants from various climate basins began to actively evolve, often, following the inadaptable scenario (Rasnitsyn, 1986). The eudemic (Callomon, 1985) neoendemics widely inhabited other regions. The western (Dnieper–Donets) area of the East European marine basin, including the area of Kanev dislocations, was a main way of migration of marine organisms between the West and East European paleobiogeographic provinces.

New guide ammonite species which occupied a key position in monophyletic evolution of their groups

(*Paracadoceras vasily* Gulyaev, sp. nov., *Sigaloceras fundator* Gulyaev, sp. nov., *S. kiselevi* Gulyaev, sp. nov.) are described as a result of revision. Thus *P. vasily* sp. nov. corresponds to a critical moment during transition from *Paracadoceras* Crickmay to *Cadochamousetia* Mitta, *S. fundator* sp. nov. is the ancestor of the genus *Sigaloceras* Hyatt, and *S. kiselevi* sp. nov. is the terminal one during transition to *Catasigaloceras* Buckman, which corresponds to the transition from Gowericeratinae Buckman to Kosmocerotinae Haug.

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