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New Data on the Age of the Ryazanian Stage Basal Layers

V. V. Mitta

Paleontological Institute, Russian Academy of Sciences, Profsoyuznaya ul. 123, Moscow, 117647 Russia

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Abstract—The *Riasanites rjasanensis* Zone, the basal one in the Ryazanian Stage, is characterized by the Boreal Craspeditidae and Tethyan Neocomitidae (Ammonoidea forms). The family Craspeditidae is represented by genera *Hectoroceras, Praesurites*, and *Pseudocraspedites*. The assemblage of the *rjasanensis* Zone is correlated with that of the *kochi* Zone and upper subzone of the *sibiricus* Zone of Siberia. The *Praetollia* and *Chetaites* Beds uppermost in the Volgian Stage of the Russian platform are probably equivalent to the *maynci* Subzone of the last zone coupled with the *chetae* Zone of Siberia. In the Russian platform, Neocomitidae s.l. are represented by genera *Riasanites*, *Subalpinites, Transcaspiites*, and others. The finds of *Dalmasicearas* ex gr. *djanelidzei* and *Malbosiceras nikolovi* suggest correlation of the *rjasanensis* Zone lower boundary with that of the *jacobi* Zone in West Europe. The *rjasanensis* Zone corresponds probably to the greater part of the Berriasian Stage to the interval spanning the *jacobi* and *occitanica* zones and the *paramimounum* Subzone of the *boissieri* Zone. Accordingly, the Volgian Stage, all three substages included, should be referred to the Jurassic System and regarded in the general scale of Boreal realm as an autonomous stage concurrent to the Tithonian Stage of Submediterranean areas.

Key words: Berriasian, Ryazanian, ammonites, biostratigraphy, Russian platform.

INTRODUCTION

The problem of Boreal–Tethyan correlation of Jurassic–Cretaceous boundary layers is still the most crucial one in Mesozoic stratigraphy. The primary reason is a sharp difference between oryctocoenoses of the terminal Jurassic (Volgian and Tithonian) and basal Cretaceous (Berriasian and Ryazanian) stages, which is determined by isolation of sea basins at that times.

The forcible decision of the Interdepartmental Stratigraphic Committee of Russia to include the upper substage of the Volgian Stage into the Cretaceous System and withdrawal of the whole stage from the general scale (*Resolution…*, 1997) had one undoubtedly positive side: it attracted attention of experts on the Jurassic stratigraphy to basal strata of the Cretaceous System. The groundlessness of this decision is now obvious (Mitta, 2001; Zakharov, 2003).

This paper is dedicated to consideration of some new data on ammonites from the *Riasanites rjasanensis* Zone, the basal zonal unit of the Ryazanian Stage, obtained in the Moscow region. It is difficult to study taxonomy and stratigraphic distribution of ammonites throughout this biostratigraphic unit because of a condensed character of relevant sections and rare finds of well-preserved fossils. The long-term study only and detailed sampling can yield strictly substantiated phylogenetic (and, accordingly, correlative) interpretations in the future. At the same time, available data presented recently at different meetings (Mitta, 2004a, 2004b, 2004c, 2004d, 2005) are of interest and open new perspectives for correlation of Jurassic–Cretaceous boundary sediments in the Boreal realm and positioning the boundary between these system.

My own field works specially dedicated to this problem commenced in 2000, although first observations and sampling of fossils were carried out in 1980 in the course of studying middle Volgian sequences. Workings of the Lopatino phosphorite mine near Voskresensk in the southeastern part of the Moscow region are main study areas discussed in the paper (Fig. 1). Quarries of the mine particularly numerous in the 1980s recovered Mesozoic sequences, primarily the lower and upper substages of the Volgian Stage, which are very convenient for research and contain diverse ammonite assemblages (Gerasimov and Mikhailov, 1966; Mitta, 1988). Unfortunately, these sections are largely flooded now or difficultly accessible. The lower part of one of these sections, which was observable not long ago, is described below.

THE ELKINO SECTION

In an excavation of Quarry 10 near the Elkino Village, there are exposed the following beds from the base upward (description of 2000, Fig. 2):

Volgian Stage, Upper Substage, Kachpurites fulgens Zone

Bed. 6. Sand, dark to greenish gray, clayey, glauconitic, with abundant concretions of loose phosphatic

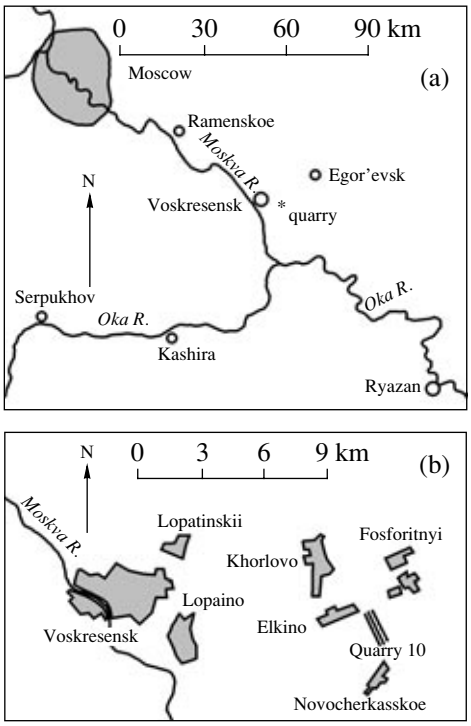

Fig. 1. Schematic maps showing the Quarry 10 locality in the Lopatino phosphorite mine: (a) general, (b) detailed.

sandstones usually enclosing casts and shells of ammonites, bivalves, and other fossils; most common ammonite species is *Kachpurites fulgens* (Trautschold) accompanied by subordinate *Craspedites* ex gr. *okensis* (d'Orbigny) and *Garniericeras catenulatum* (Fisher de Waldheim).The apparent thickness is 0.5 m (according to description of 1986, the maximal thickness is up to 1.9 m from the top of the *Epivirgatites nikitini* Zone).

Craspedites subditus Zone

Bed 7a. Sand, dark to greenish gray, vaguely bedded, ocherous to reddish brown at bedding planes, phosphatized, irregularly cemented. Along the strike, there are inclusions and lenses of dark gray clayey sand. The bed encloses abundant *Buchia, Lima*, and subordinate ammonite species *Craspedites subditus* (Trautschold) and *Garniericeras catenulatum* (Fisher de Waldheim); fossils are noticeably less frequent in the upper part of the bed that is 0.85 m thick.

? Craspedites nodiger Zone

Bed 7b. Clay, dark gray, slightly sandy, grading into clayey sand along the strike; bed is 0–0.1 m thick.

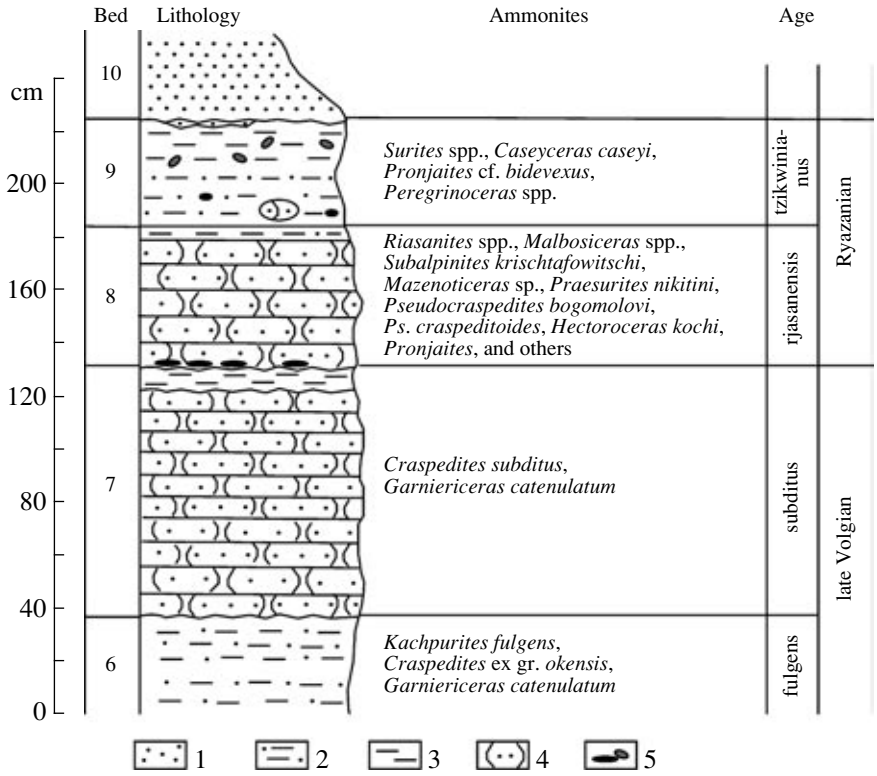

Fig. 2. Succession of upper Volgian–Ryazanian sediments in Quarry 10, the Lopatino phosphorite mine (observations of 2000): (1) sand; (2) clayey sand; (3) clay; (4) sandstone; (5) phosphorite nodules.

Ryazanian Stage, Riasanites rjasanensis Zone

Bed 8a. Phosphorite nodules, dark brown to almost black, very compact, with occasional fragments of *Riasanites* sp. and *Hectoroceras* sp. undeterminable at the species level. Thickness is 0–0.05 m.

Bed 8b. Sandstone, yellowish–reddish brown, inequigranular, with ferruginous ooliths, obscurely bedded, phosphatized, locally very compact or loose, containing dark compact phosphorite nodules. The rock is saturated with fossils: bivalves, subordinate brachiopods, gastropods, pseudophragmocones, and occasional belemnite rostra. Ammonites are most common in the lower third of the bed, where intact shells of *Riasanites rjasanensis* (Nikitin), *R. swistowianus* (Nikitin), less common *Subalpinites krischtofovitschi* Mitta, *Malbosiceras* spp., *Mazenoticeras* sp., *Praesurites nikitini* (Gerasimov) em. Mitta, *Pseudocraspedites bogomolovi* Mitta, *Ps. craspeditoides* Girmounsky, and others occur along with their abundant, usually rounded fragments. Thickness is 0.35–0.55 m.

Bed 8c. Dark clay, brownish, sandy, grading into inequigranular clay-rich sand along the strike, enclosing rare *Pronjaites bidevexus* (Bogoslovsky). Thickness is 0–0.1 m.

Surites tzikwinianus Zone

Bed 9a. Sand, clayey, cementing brown compact phosphate nodules with ferruginous ooliths and rare fragments of *Riasanites* sp. redeposited from the *rjasanensis* Zone. Cement contains rare *Pronjaites* cf. *bidevexus* (Bogoslovsky), and *Surites* ex gr. *spasskensis* (Nikitin). Thickness is 0.1–0.4 m.

Bed 9b. Clay, yellowish to brownish gray or greenish locally and in some beds containing glauconite; clay is sandy, frequently micaceous, grading via interfingering into slightly lithified clayey sandstone and sand along the strike. The upper part of the bed encloses sometimes a "weathering crust" 3–5 cm thick, represented by massive compact clayey, usually gray sandstone with gray, greenish gray, brown, yellowish rusty–red, and black spots. Fossils are represented by bivalve casts, poorly preserved belemnite rostra, rare ammonites *Surites* spp., *Caseyceras casey* Sasonova and *Peregrinoceras* spp. Thickness is 0–0.4 m.

? Hauterivian Stage

Bed 10. Sand, light gray to gray, irregularly colored, quartzose, medium-grained. The apparent thickness up to the top of the quarry is 0.1 m (the bed continues higher in the excavation wall).

DISCUSSION

The lower, most likely highly condensed part of Bed 8b is most remarkable because of abundance and diversity of ammonites. Precisely this interval yields most ammonite species of the *Riasanites rjasanensis* Zone. Two ammonite groups of different origin occur only in this unit. On the one hand, the ammonite assemblage contains descendants of the Boreal family Craspeditidae that appeared in the Central Russian sea in the Volgian time (Mitta, 1993) and became widespread in the Boreal realm during the late Volgian–Early Cretaceous. On the other, it includes also species of the family Neocomitidae s.l. (subfamily Berriasellinae included) that migrated to the Central Russian basin as a short-term invasion from the Tethyan margin. It should be noted that finds of ammonites are sporadic. Their taxonomic composition is variable within the quarry and especially in different quarries of the mine.

Hectoroceras forms and typical representatives of genera *Praesurites* and *Pseudocraspedites* are identified among the studied Craspeditidae. Let us consider distribution of these taxa.

The genus *Hectoroceras* was first described from eastern Greenland (Spath, 1947). Stratigraphic range of the genus is now considered as spanning the lower Berriasian (Boreal). *Hectoroceras* forms are widespread in the Boreal realm, northern Siberia included (Shul'gina, 1972). In the Russian platform, (Oka River basin, Ryazan oblast), doubtless *Hectoroceras* forms were found first in the *rjasanensis* Zone by paleontologists headed by M.S. Mesezhnikov (Casey *et al.*, 1977, Plate 1, fig. 4; Plate 2, fig. 6; Mesezhnikov *et al.* Plate 1, figs. 5, 7). *Schulginites* also described from the *rjasanensis* Zone of the Oka River basin (Mesezhnikov *et al.*, 1983, Plate 6, fig. 4) should be probably viewed as a subjective synonym of *Hectoroceras.* Correlation of the Central Russian (Subboreal) *rjasanensis* Zone with the *kochi* Zone in the Boreal scale is based precisely on representatives of this genus found in the Oka River basin. However, does the *rjasanensis* Zone of the Russian platform correspond only to the *kochi* Zone of Siberia? Typical *Praesurites* (Plate I, figs. 5, 6) and *Pseudocraspedites* forms (Plate I, figs. 4, 7) found in sections of the Moscow region imply that stratigraphic range of the Central Russian zone should be definitely widened relative to the above biostratigraphic unit of North Siberia (Mitta, 2004b).

Praesurites elegans Mesezhnikov et Alekseev, the type species of the genus *Praesurites* is described from the *Chetaites sibiricus* Zone established in the western flank of the Subpolar Urals (Mesezhnikov *et al.*, 1983). Morphological difference between this species and *P. nikitini* (Gerasimov) em. Mitta from central Russia are almost negligible, most likely of geographic nature. *Pseudocraspedites anglicus* (type species of the monospecies genus de jure) is also very similar to *Ps. bogomolovi* Mitta and *Ps. craspeditoides* (Girmounsky) of central Russia and occurs in the middle–upper interval of *Hectoroceras kochi* Zone (Casey *et al.*, 1988). Thus,

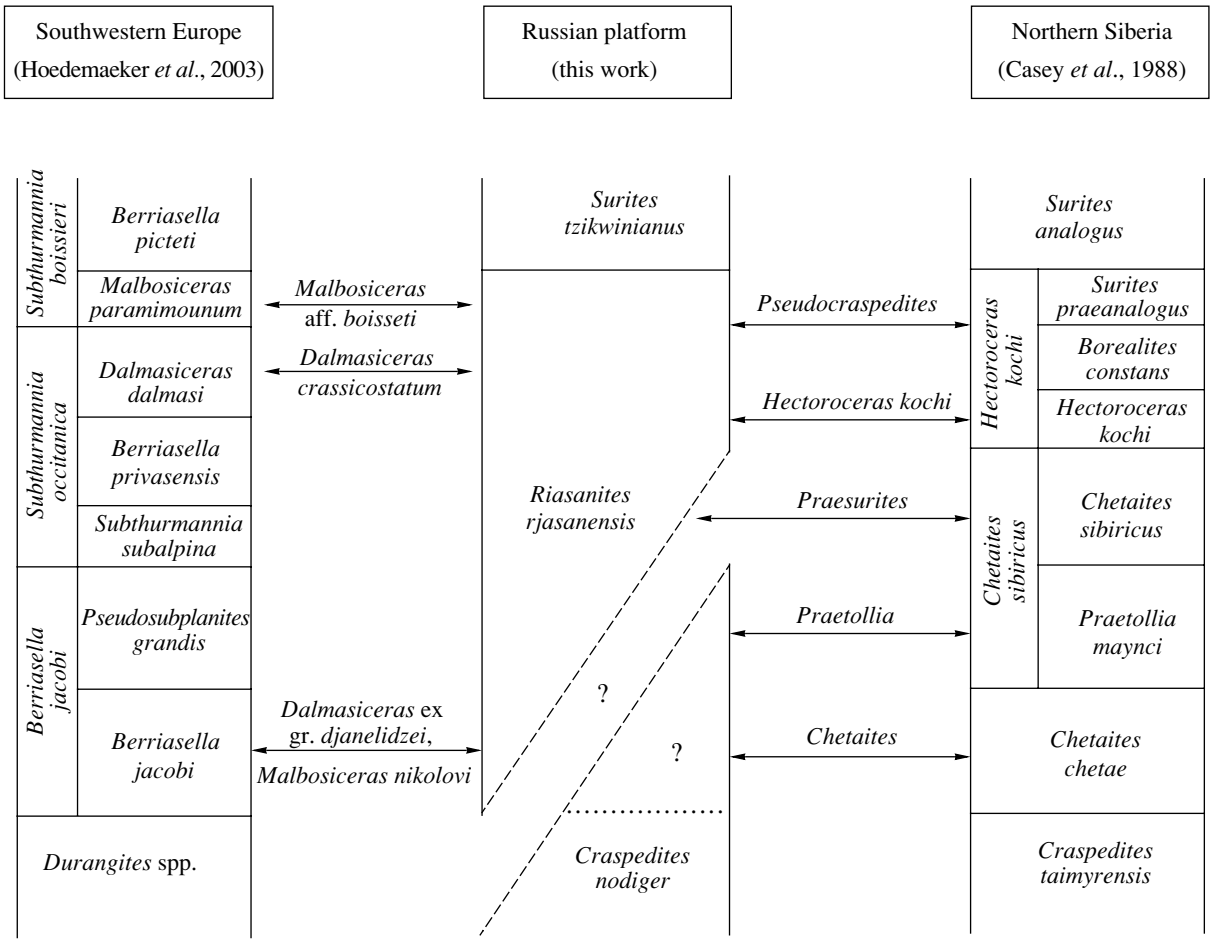

Fig. 3. Correlation of the *Riasanites rjasanensis* Zone, the Ryazanian Stage of the Russian platform, with the standard Berriasian (southwestern Europe) and "Boreal Berriasian" (northern Siberia) stages.

it can be assumed that the *rjasanensis* Zone of central Russia is correlative with the upper subzone of the *sibiricus* Zone coupled, at least, with two lower subzones of the *kochi* Zone (Fig. 3).

The *Praetollia maynci* Subzone of the *Chetaites sibiricus* Zone and the *Chetaites chetae* Zone, the lower stratigraphic units in the Siberian scale, have also a probable equivalent in the Russian platform. *Praetollia olivikorum* Mitta (Plate I, fig. 1) is first described from the phosphorite plate of the uppermost Volgian Stage in the Unzha River basin of the Kostroma oblast, where it occurs along with ammonites of the *Craspedites nodiger* Zone, being in different preservation state in distinction from the latter (casts without nacre). According to Alekseev (1984), representatives of the genus *Praetollia* are characteristic of the *maynci* Subzone of the *sibiricus* Zone in northern Siberia.

Chetaites forms are known from the same area (Kozlovo-Korshunskoe and Ogarkovo villages at the Unzha River) and originate, judging from their preservation state, from the same phosphorite plate. These are *"Perisphinctes* aff. *Stschurovskii* Nik." (Nikitin, 1885, Plate 4, fig. 17) and "*Craspedites* sp. nov. =? *Ammonites* aff. *Stschurovskii* Nik." (Sokolov, 1929, p. 21).[1] Arkhangel'sky (1909, p. 21) mentioned (with reference to determination by A.N. Rozanov) "*Perisphinctes* cf. *Stschurovskii* Nik." (presumably *Chetaites*) from "Neocomian phosphorites" exposed in the Volga River bank between towns of Kineshma and Navoloki.

Thus, ammonite assemblages from the Russian platform are very similar to those of the "classical" Boreal type (the so-called "Boreal Berriasian"). At the same time, the "Subboreal" Berriasian succession of central Russia is more advantageous than the Boreal one, because ammonites at its base are of a more clear "Berriasian" affinity. These are Neocomitidae (s. l.) forms of undoubted "Tethyan" origin, which originated from the Tithonian but not Volgian perisphinctoids.

It is incredible, but ammonoids of central Russia, which could solve the problem of correlation between

[1] I identified this small ammonite species, that was never illustrated, in the collection of M.I. Sokolov stored in the Vernadsky Geological Museum, Moscow. Here, it is pictured as *Chetaites* cf./aff. *chetae* Schulgina (Table I fig. 2).

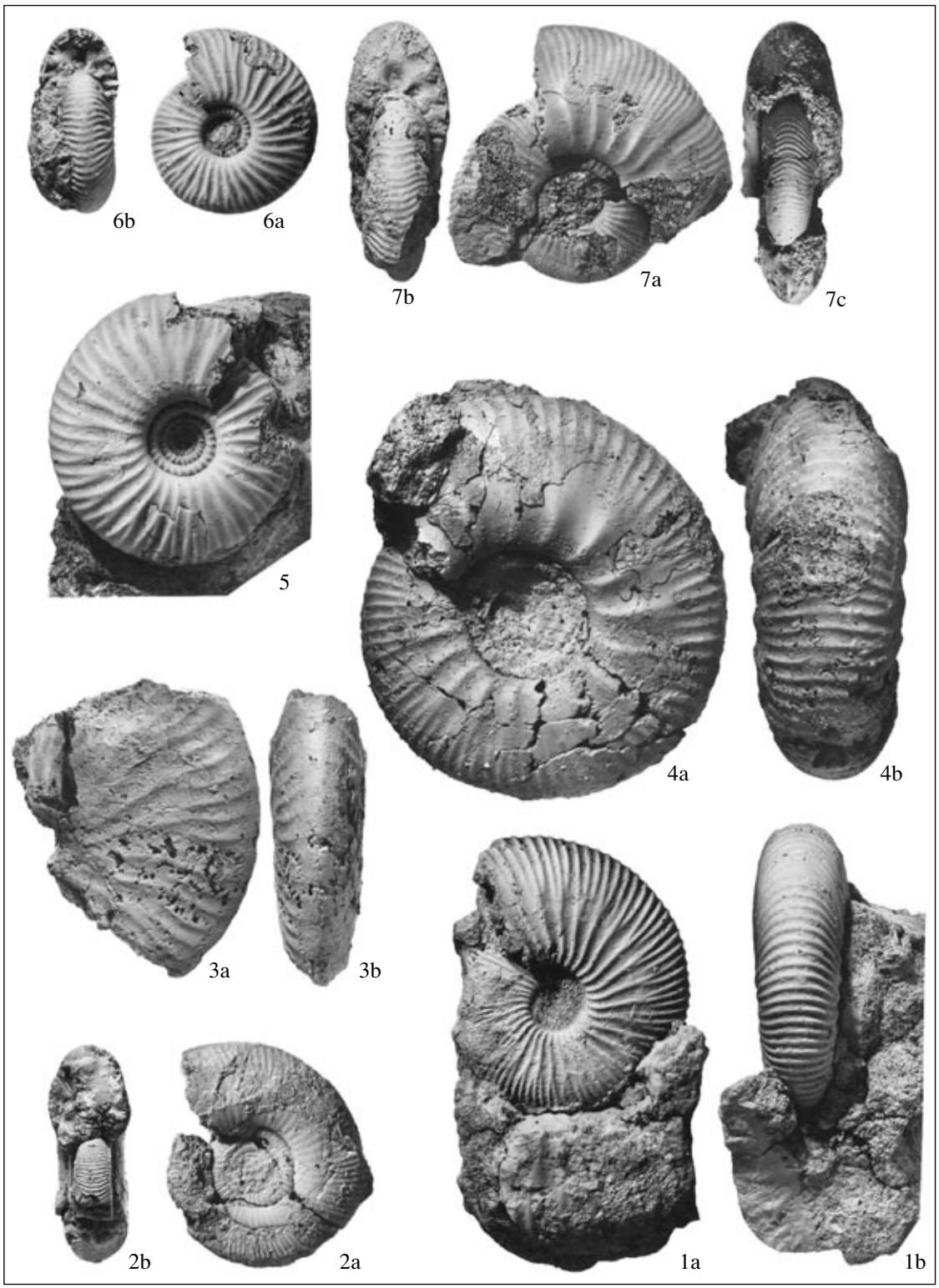

Plate I. Boreal ammonites from the Jurassic–Cretaceous boundary beds of the Russian platform:

(1) *Praetollia olivikorum* Mitta, holotype, Paleontological Institute (PIN RAS), specimen 3990/238: (a) side view, (b–c) ventral view. (2) *Chetaites* cf. *chatae* Schulgina, State Geological Museum (SGM), specimen 231/163: (a) side view, (b) apertural view. (3) *Hectoroceras* cf. *kochi* Spath, PIN RAS, specimen 3900/233: (a) side view, (b) ventral view. (4) *Pseudocraspedites craspeditoides* (Girmounsky), PIN RAS, specimen 3900/244: (a) side view, (b–c) ventral view. (5, 6) *Praesurites nikitini* (Gerassimov) em. Mitta: (5) PIN RAS, specimen 3900/236: (a) side view, (6) PIN RAS, specimen 3900/237: (a) side view, (b) apertural view. (7) *Pseudocraspedites bogomolovi* Mitta, PIN RAS, specimen 3900/243: (a) side view, (b) apertural view, (c) ventral view. (1, 2) Kostroma region, bank of the Unzha River between the Ogarkovo and Efimovo villages; phosphorite plate at the top of the Volgian Stage; (3–7) Moscow region, Lopatino phosphorite deposit, Ryazanian Stage, *rjasanensis* Zone. All the shown specimens are represented by phragmocones (natural size).

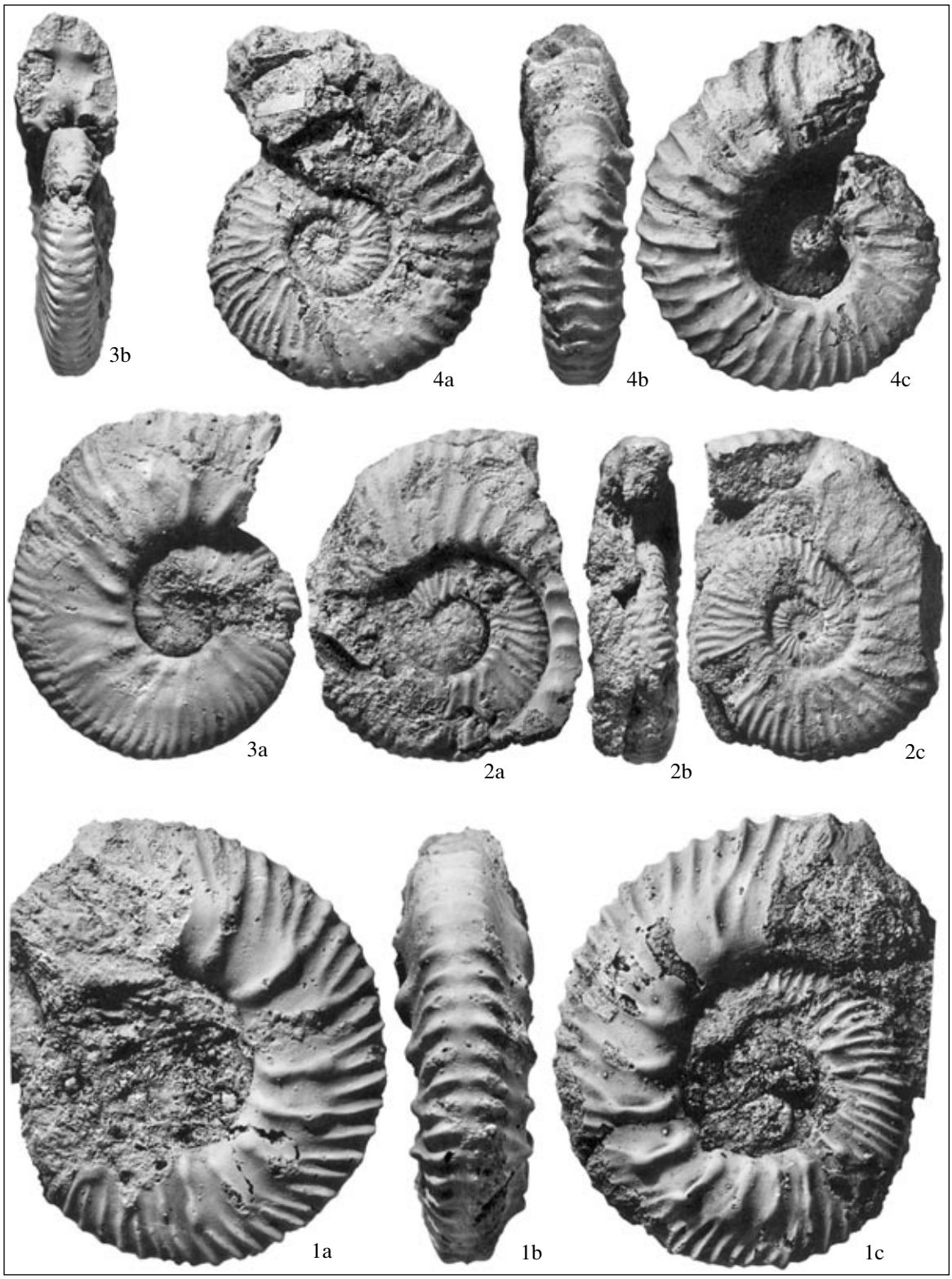

Plate II. Tethyan ammonites from the basal sediments of Berriasian Stage of the Russian platform:
(1) *Malbosiceras* aff. *boisseti* (Nikolov), PIN RAS, specimen 3900/246: (a, c) side view, (b) ventral view. (2) *Dalmasiceras* ex gr. *djanelidzei* (Mazenot), PIN RAS, specimen 3900/249: (a, c) side view, (b) apertural view. (3) *Dalmasiceras crassicostatum* (Djanelidze), PIN RAS, specimen 3900/247: (a, c) side view, (b) ventral view. (4) *Malbosiceras nikolovi* Le Hegarat, PIN RAS, specimen 3900/248: (a, c) side view, (b) ventral view. All specimens originate from the Moscow region, Lopatino phosphorite deposit, Ryazanian Stage, *rjasanensis* Zone. All images are of natural size.

the Berriasian and Ryazanian stages, attracted attention of researchers just occasionally. During the last century, diagnostic features of several species have been described in a single work only (Sazonova, 1977), and collection of Bogoslovsky (1897) has not been revised properly so far. In fact, neocomitids and related taxa from the Russian platform, which have been collected in the last two centuries, are properly described and illustrated in three publications only, the first description of *Riasanites* forms by Nikitin (1888) included.

In Russia, researchers usually correlate the *rjasanensis* Zone of the Russian platform with the *paramimounum* Subzone of the *boissieri* Zone of the standard Berriasian Stage. The main, if not a single argument in favor of such a correlation, is occurrence of *Euthymiceras euthymi* (Pitctet) in the Oka River sections. Nevertheless, representatives of this genus from central Russia have never been mentioned as synonyms by West European researchers (Le Hegarat, 1973; Nikolov, 1982). This is understandable, because shell fragments figured in Russian publications cannot be classed with the species *E. euthymi* or the genus *Euthymiceras.* For example, *Euthymiceras* sp. indet. figured in the work by Mesezhnikov *et al.* (1979, Plate 1, figs. 1, 2) represent undoubtedly the genus *Riasanites*.

Data reported on *Euthymiceras euthymi*, the type species included, provide no grounds to consider this taxon as studied well and, consequently, as suitable for a reliable correlation. According to Le Hegarat (Le Hegarat, *loc. cit.*), this genus is represented only by the nominative species known from limited specimens. In opinion of Tavera Benitez (1985), the species should be actually referred to the genus *Neocosmoceras* Blanchet, 1922. It is conceivable therefore that the genus *Euthymiceras* Grigorieva, 1938, is a synonym of either *Mazenoticeras* Nikolov, 1966, or *Malbosiceras* Grigorieva, 1938. Classification of these Berriasian ammonites is ambiguous so far, and their genera are frequently lacking clear diagnoses and certainly defined position in phyletic lineages.

According to my own sampling, the *rjasanensis* Zone of the Moscow region yields diverse ammonite taxa of Tethyan origin. In addition to common *Riasanites* forms and ammonites described as *Subalpinites* species (Mitta, 2002), the *rjasanensis* Zone contains occasional specimens of other taxa. Found specimens of *Dalmasiceras crassicostatum* Djanelidze (Plate II, fig. 3) suggest that the *rjasanensis* Zone lower boundary can be displaced down to the base of the *Dalmasiceras dalmasi* Subzone of the *occitanica* Zone of the standard Berriasian scale (Fig. 3). First found *Malbosiceras nikolovi* Le Hegarat (Plate II, fig. 4) and *Dalmasiceras* ex gr. *djanelidzei* (Mazenot) (ditto, fig. 2) admit correlation between lower boundaries of the *rjasanensis* Zone and *jacobi/grandis* (=jacobi) Zone of West Europe. On the other hand, *Malbosiceras* aff. *boisseti* (Nikolov) occurring in the unit (Mitta, 2002, Plate 3, fig. 4; Plate II, fig. 1 in this work) imply a possibility to correlate the *rjasanensis* Zone with the *paramimounum* Subzone of the *boissieri* Zone in the standard Berriasian scale.

The comparative study of taxonomy and distribution of ammonites in the *rjasanensis* Zone of the Moscow region and the Ryazanian Stage lectostratotype at the Oka River (near the Chevkino Village, Ryazan oblast) revealed substantial changes in composition of oryctocoenoses buried in western and eastern sites (Mitta, 2005). In the Moskva River basin, the zone (more exactly, Bed 8b in its lower part; in the upper part ammonites are rare) yields mainly the "Tethyan" *Riasanites* forms (*R. swistowianus*, less commonly *R. rjasanensis*), *Subalpinites* spp., *Mazenoticeras* spp., *Pseudosubplanites ?* sp., *Dalmasiceras* ex gr. *djanelidzei,* and "Boreal" species *Praesurites nikitini* and *Pseudocraspedites* spp. In the Oka River outcrops, ammonites of the Tethyan origin are usually represented by *Riasanites rjasanensis*, that is younger (?) morphotype as compared to that from the Moscow region, and by *Transcaspiites* spp. Boreal species of this assemblage are *Surites* ex gr. *spasskensis*, Externiceras, "Gerassimovia," and *Peregrinoceras* spp. Forms in common for both areas are *Hectoroceras* and *Pronjaites* ex gr. *bidevexus*, which are inadequately studied however. The Pronya River sections (near the town of Mikhailov, Ryazan oblast), which are of intermediate geographic position but studied insufficiently so far, contain oryctocoenoses compositionally similar to those from the Moscow region. Difference between ammonite assemblages found 100 to 200 km away from each other are hardly of geographic origin. In terms of phylogeny, Boreal ammonites from the *rjasanensis* Zone of the Moscow region are close to their late Volgian ancestors (genus *Craspedites*) in distinction from *Surites, Peregrinoceras*, and other forms, which transit into the overlying *Surites tzikwinianus* Zone. Consequently, it is logical to suggest the age difference (at infrazonal level) between stratigraphic units of the Moscow region and stratotype area, which are under consideration.

The *Riasanites rjasanensis* stratigraphic range in the northern Caucasus used to be correlated with the lower half of the *boissieri* Zone of the standard Berriasian scale (*The Berriasian of the North Caucasus*…, 2002). *R. swistowianus* is confined, however, to the zone upper part (several specimens up to 30 mm in diameter), but the only illustrated specimen (*loc. cit.*, Plate 14, fig. 4) hardly belongs to these species and genus. According to my own observations, species *R. swistowianus* and *R. rjasanensis* occur separately in different lenses, and the former is most likely phylogenetic and stratigraphic ancestor of the latter. Data on the *swistowianus–rjasanensis* lineage confirm therefore my idea that the *rjasanensis* Zone of central Russia is correlative with older biostratigraphic subdivisions of the Berriasian Stage. Moreover, the widespread, though unsubstantiated opinion that *Riasanites* species origi-

nated in the northern Caucasus and then migrated to the Central Russian sea seems doubtful.

A thorough study of Tethyan ammonites from the Russian platform is only at the beginning and determinations of their taxa presented above are preliminary. Nevertheless, they lead to some remarkable conclusions.

CONCLUSIONS

(1) Representatives of genera *Hectoroceras, Praesurites*, and *Pseudocraspedites* imply that ammonite assemblage from the *Riasanites rjasanensis* Zone of the Russian platform is correlative with assemblages from the *Hectoroceras kochi* Zone and *Chetaites sibiricus* Subzone of the synonymous zone of Siberia. The lower *Praetollia maynci* Subzone and *Chetaites chetae* Zone of Siberia may span in the Russian platform the interval of unnamed stratigraphic unit below the *rjasanensis* Zone and *Praetollia* to *Chetaites* Beds at the top of the Volgian Stage.

(2) The undoubtedly condensed character of the *Riasanites rjasanensis* Zone in central Russia and ammonites *Malbosiceras nikolovi, M.* aff. *boisseti*, *Dalmasiceras crassicostatum*, and *D.* ex gr. *djanelidzei* in this unit suggest that it corresponds in range to the greater part of the Berriasian Stage and spans the *Berriasella jacobi* and *Subthurmannia occitanica* zones coupled with the *Malbosiceras paramimounum* Subzone of the *Subthurmannia boissieri* Zone.

(3) Accordingly, the Volgian Stage with its three substages should be referred to the Jurassic System and regarded in the general scale of Boreal realm as a valid stage subdivision concurrent to the Tithonian Stage of Submediterranean areas.

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and M.A. Rogov

REFERENCES

1. S. N. Alekseev, "New Data on Zonation of the Berriasian Stage in Northern Siberia," in *Boundary Stages between the Jurassic and Cretaceous Systems* (Nauka, Moscow, 1984), pp. 81–106 [in Russian].
2. A. D. Arkhangel'sky, "Geological Description of Phosphorite-Bearing Sediments of the Kostroma Region along the Volga River west of Kineshma and along the Mera River," in *Proceedings of Commission of the Moscow Institute of Phosphorite Research, Report on Geological Studies of Phosphorite Deposits* (Moscow, 1909), Issue 1, pp. 17–69 [in Russian].
3. N. A. Bogoslovsky, "The Ryazanian Horizon. Fauna, Stratigraphic Relationships, and Probable Age," Materials on Geology of Russia **18**, 100–157 (1897).
4. R. Casey, M. S. Mesezhnikov, and N. I. Schul'gina, "Correlation of Jurassic–Cretaceous Boundary Layers in England, Russian Platform, Subpolar Urals, and Siberia," Izv. Akad. Nauk SSSR, Ser. Geol., No. 7, 14–33 (1977).
5. R. Casey, M. S. Mesezhnikov, and N. I. Schul'gina, "Ammonite Zonation of Jurassic–Cretaceous Boundary Layers in the Boreal Realm," Izv. Akad. Nauk SSSR, Ser. Geol., No. 10, 71–84 (1988).
6. P. A. Gerasimov and N. P. Mikhailov, "The Volgian Stage and General Stratigraphic Scale of the Upper Jurassic," Izv. Akad. Nauk SSSR, Ser. Geol., No. 2, 118–138 (1996).
7. P. J. Hoedemaeker, S. Reboulet, M. B. Aguirre-Urreta, *et al.*, "Report on the 1st International Workshop of the IUGS Lower Cretaceous Ammonite Working Group, the "Kilian Group" (Lyon 11 July 2002)," Cretaceous Res. **24**, 89–94 (2003).
8. J. Le Hegarat, "Le Berriasien du sud-east de la France," Doc. Lab. Geol. Fac. Sci. Lyon," No. 43 (fasc. 1–2 for 1971), 1971 (1973).
9. M. S. Mesezhnikov, V. A. Zakharov, N. I. Shul'gina, and S. N. Alekseev, "Stratigraphy of the Ryazanian Horizon, the Oka River Sections," in *The Upper Jurassic and Its Boundary with the Cretaceous System* (Nauka, Novosibirsk, 1979), pp. 71–81 [in Russian].
10. M. S. Mesezhnikov, S. N. Alekseev, I. G. Klimova, *et al.*, "On Development of Some Craspeditidae in the Jurassic–Cretaceous Boundary Period," in *The Mesozoic of the Soviet Arctic* (Nauka, Novosibirsk, 1983), pp. 103–125 [in Russian].
11. V. V. Mitta, "The *Virgatites gerassimovi* Beds of the Volgian Stage in the Moscow Region," Izv. Akad. Nauk SSSR, Geol., No. 3, 138–139 (1988).
12. V. V. Mitta, *Ammonites and Zonal Stratigraphy of Middle Volgian Sediments in Central Russia* (Geoprognoz, Kiev, 1993) [in Russian].
13. V. V. Mitta, "Ammonite Assemblages from Jurassic–Cretaceous Boundary Layers and the Problem of the Jurassic–Cretaceous Boundary," in *Problems of Stratigraphy and Paleogeography of the Boreal Mesozoic* (SO RAS, Novosibirsk, 2001), pp. 24–25 [in Russian].
14. V. V. Mitta, "New Data on Berriasian Neocomitidae (Ammonoidea) from the Moscow Region," Paleontol. Zh., No. 4, 30–33 (2002).
15. V. V. Mitta, "On Probable Isochronism of the Berriasian and Ryazanian Basal Levels," in *Proceedings of the Second All-Russia Meeting on the Cretaceous System of Russia: Problems of Stratigraphy and Paleogeography* (St. Petersburg Gos. Univ., St. Petersburg, 2004a).

16. V. V. Mitta, "On Succession of Ammonite Assemblages in Jurassic–Cretaceous Layers of the Moscow Syneclise," Paleontol. Zh., No. 5, 17–24 (2002b).
17. V. V. Mitta, "Ammonites and Stratigraphy of Boundary Layers between the Volgian and Ryazanian Stages," in "Materials of the Scientific–Practical Conference "Problems of Regional Geology: A Museum Aspect" Moscow Vernadsky Geol. Museum," (GGM RAN, Moscow, 2004c), pp. 166–168 [in Russian].
18. V. V. Mitta, "The Jurassic–Cretaceous Boundary Beds on the Russian Platform," in 32nd Intern. Geol. Congress, Florence, 2004. Abstract Vol. (CD) (Florence, 2004d), Pt. 1, p. 338.
19. V. V. Mitta, "Ammonites of Tethyan and Boreal Origin in the Ryazanian Horizon of the Moscow and Ryazan Regions," in *Paleostrat-2005. Program and Abstracts of the Annual Meeting of MOIP Paleontological section and Moscow Section of the Paleontological Society* (PIN RAN, Moscow, 2005), pp. 25–26 [in Russian].
20. S. N. Nikitin, "The General Geological Map of Russia," Proc. Geol. Committee **2** (1), 1–218 (1885).
21. S. N. Nikitin, "Traces of the Cretaceous Period in Central Russia," Proc. Geol. Committee **5** (2), 1–205(1888).
22. T. G. Nikolov, *Les ammonites de la famille Berriasellidae Spath, 1922: Tithonique supérier–Berrisasien* (Acad. Bulg. Sci., Sofia, 1982).
23. "Resolution on the Specified Position of the Jurassic–Cretaceous Boundary in the Boreal Realm and the Volgian Stage Status," in *Resolutions of the Interdepartmental Stratigraphic Committee and its Permanent Commissions* (VSEGEI, St. Petersburg, 1997), Issue 29, pp. 5–7 [in Russian].
24. I. G. Sazonova, *Ammonites from the Jurassic–Cretaceous Boundary Beds of the Russian Platform* (Nedra, Moscow, 1977) [in Russian].
25. N. I. Shul'gina, "Ammonites of Northern Central Siberia," in *The Jurassic–Cretaceous Boundary and Berriasian Stage in the Boreal Realm* (Nauka, Novosibirsk, 1972), pp. 137–175 [in Russian].
26. M. I. Sokolov, "Geological Research along the Unzha River in 1925," Izv. Ass. NII pri 1-m MSU **2** (1), 5–31 (1929).
27. L. F. Spath, "Additional Observations on the Invertebrates (Chiefly Ammonites) of the Jurassic and Cretaceous of East Greenland, 1. The *Hectoroceras* Fauna of S.W. Jameson Land," Medd. Grønland **132** (3), 1–69 (1947).
28. *The Berriasian of the North Caucasus (Urukh Section): Biochronology and Correlation of the Phanerozoic in Oil-and-Gas Basins of Russia* (VNIGRI, St. Petersburg, 2000), Issue 2 [in Russian].
29. J. M. Tavera Benitez, *Les ammonites del Tithonico superior–Berriasense de la Zona Subbetica* (Cordilleras Bettica). Tesis Doct. (Univ. Canada, 1985).
30. V. A. Zakharov, "In Defense of the Volgian Stage," Stratigr. Geol. Korrelyatsiya **11** (6), 60–69 (2003) [Stratigr. Geol. Correlation **11**, 585–593 (2003)].