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3 authors, including:

Liubov Bragina
Russian Academy of Sciences

Andrei Zastrozhnov
A.P. Karpinsky Russian Geological Research Institute

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The Upper Cretaceous Radiolarians, Foraminifers, and Stratigraphy of the Southeastern Russian Plate, the Right-Bank Volga Region near Volgograd

L. G. Bragina*, V. N. Ben'yamovskii*, and A. S. Zastrozhnov**
** Geological Institute (GIN), Russian Academy of Sciences, Pyzhevskii per. 7, Moscow, 109017 Russia*
*** Volgograd Hydrogeological Expedition, ul. Nezhdanovoi 8, Volgograd, 400135 Russia*
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Abstract—Paleontological study of the Upper Cretaceous sediments from wells 502 and 28 in the Volgograd region revealed distinct radiolarian and foraminiferal assemblages. Two stratigraphic levels, Coniacian-Santonian and upper Campanian, are recognized on the basis of radiolarians. Foraminiferal and radiolarian zones of the same section are first correlated to each other in the Volgograd region, and coeval assemblages from the Moscow syneclise and Volgograd region are compared.

Key words: *Upper Cretaceous, stratigraphy, radiolarians, foraminifers, European paleobiogeographical area, Volga region*

The Upper Cretaceous sediments of the studied region are represented by three lithostratigraphic units. The lower one is arenaceous, the middle is carbonate, and the upper unit that constitutes the major part of the section is composed of siliceous clayey and silty arenaceous rocks. The middle, Turonian-Coniacian unit, yields foraminifers. Radiolarians were encountered at several levels of the upper unit. These two microfossil groups are of great importance for the age determination of the studied sediments.

The latest research (Bragina, 1987, 1994; Vishnevskaya and Kazintsova, 1990) showed that the Late Cretaceous radiolarians require a more thorough investigation. Up to now, the Cretaceous radiolarian zonation in the Russian plate is not developed. Therefore, when estimating age of fossil assemblages, paleontologists use zonations suggested for subtropical and tropical areas notably remote from the study region. To develop a similar Cretaceous zonation for the Russian plate, it is necessary to reveal the radiolarian assemblages, whose stratigraphic position in the section is defined on the basis of associated traditional fossil groups. This paper is an attempt to approximate the solution to the problem. The sections of boreholes drilled near Volgograd, namely, Well 502 (the Zarya Village) and Well 28 (the Peskovatka Village) were basic objects for the investigation.

We suggest to divide the Upper Cretaceous sediments into the following units: (1) the Peskovatka sequence of the Albian–Cenomanian sands and limestones; (2) the Dubovka sequence (Turonian-Coniacian and lower Santonian limestones and marls) named for the Dubovka Village adjacent to Well 28 that penetrated the complete section of the sequence; (3) the Nariman sequence (Santonian and lower Campanian clays and argillites) named after the Nariman Village; (4) the Zarya sequence (upper Campanian clays and siltstones) named after the Zarya Village adjacent to Well 502; and (5) the Bereslavka sequence (upper Campanian and Maastrichtian silts and sands) named after the Bereslavka Village, which is situated 10 km north of Well 502.

Let us consider these lithostratigraphic units penetrated by Well 28 near the Peskovatka Village. The studied Upper Cretaceous section (see the figure) is described upward from the base.

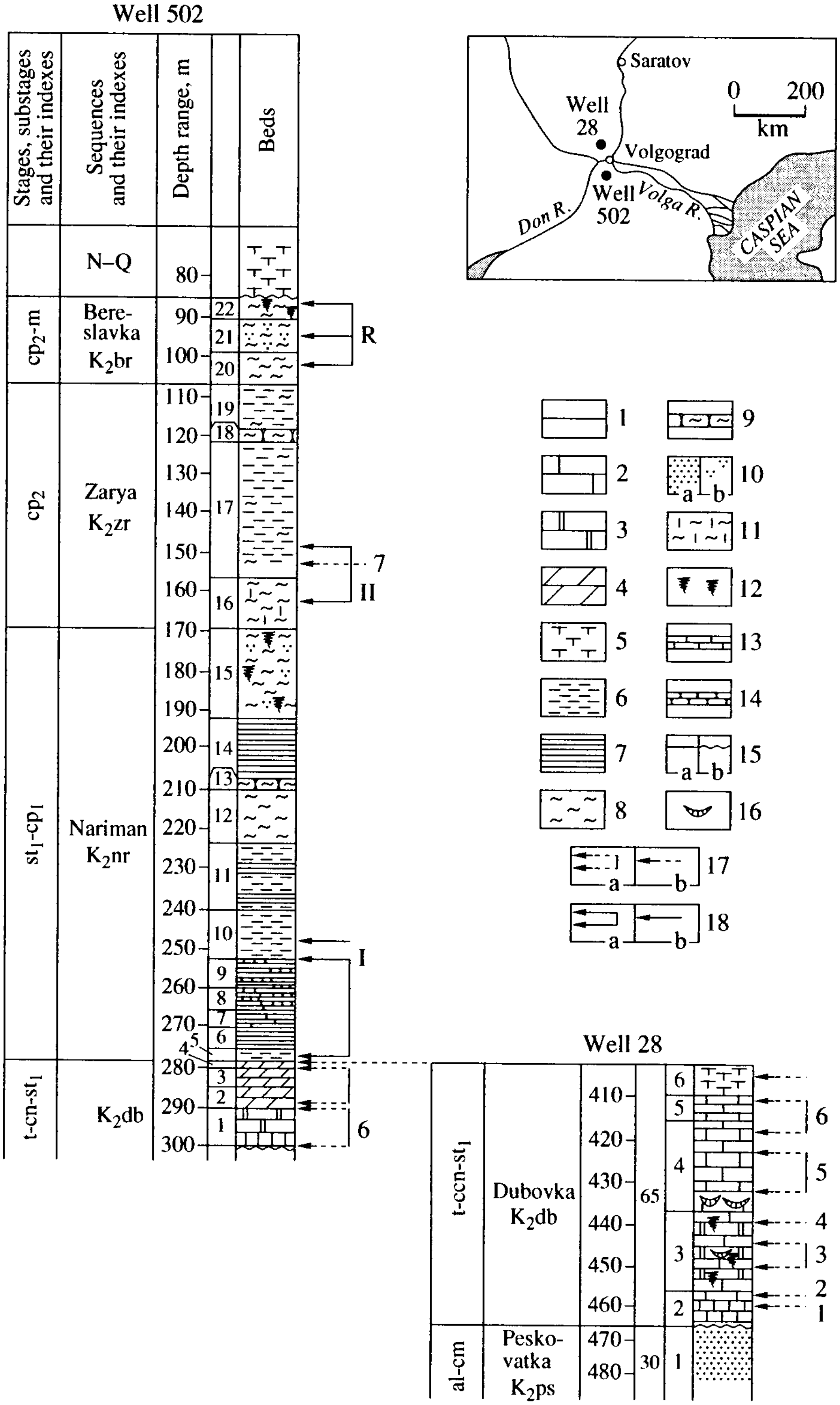
The Peskovatka Sequence

Bed 1 (depth range from 494 to 465 m): greenish gray quartz sands, fine-grained, at the top, green and bearing glauconite; the thickness is 25 m.

The Dubovka Sequence

Bed 2 (depth range from 465 to 457 m): grayish white loose chalk with the basal layer of sandy chalk grading into calcareous sandstone; at a depth of 461 m the foraminifer assemblage of the *Hedbergella holzli* Zone was found. The assemblage includes the following characteristic planktonic foraminifers: *Hedbergella paradubia* Sigal, *H. bornholmensis* Douglas, *H.* aff. *caspia* (Vassilenko), and *Rugoglobigerina ordinaria* Subbotina. The thickess is 8 m.

The sample from the depth of 458 m yielded foraminifer species missing below: *Arenobulimina presli*



Sections of wells 502 and 28 with their localities indicated in the inset map: (1) chalklike limestone; (2) limestone; (3) calcareous chalk; (4) siliceous marl; (5) carbonate clay; (6) silty clay; (7) argillite; (8) clayey silt; (9) glauconitic siltstone; (10) sand (a) and glauconitic sand (b); (11) calcareous silt; (12) bioturbation; (13) slightly calcareous argillite; (14) silty argillite; (15) conformable (a) and unconformable (b) boundaries; (16) inoceram fragments; (17) foraminifer findings (a) and beds (b); (18) radiolarian findings (a) and beds (b).

(Reuss), *A. orbignyi* (Reuss), and *Gavelinella moniliformis* (Reuss), which make it possible to correlate the host sediments with the *Gavelinella moniliformis* Zone. The thickness is 8 m.

Bed 3 (depth range from 457 to 435 m): light-gray chalklike limestones displaying strong bioturbation and bearing inoceram fragments and crinoid columals. In the interval from 450 to 445 m, sediments contain the foraminifer assemblage of the *Ataxophragmium nautiloides* Zone with characteristic species *Marssonella* sp., *M. oxycona* (Reuss), *M. araksensis* Azizbekova, *Ataxophragmium nautiloides* Vassilenko, and *Gavelinella kelleri* (Mjatliuk). The first occurrence of *Gavelinella praeinfrasantonica* (Mjatliuk) was recorded at a depth of 440 m. The thickness is 22 m.

Bed 4 (depth range from 435 to 412 m): light-gray to greenish limestones, dense, massive, with thin (0.4–0.1 m) interlayers of clayey darker limestones. The strongly bioturbated and inoceram fragment-crammed limestone layer occurs at a depth of 433.5 m. At the depth of 433 and 424 m, the foraminifer assemblage of the *Stensioeina granulata granulata* Zone is found. It includes the following species: *Ataxophragmium compactum* Brotzen, *Stensioeina granulata granulata* (Olbertz), *Gyroidina turgida* (Hagenow), *Osangularia whitei* (Brotzen), and *Gavelinella infrasantonica* (Balakhmatova).

At a depth of 418 m, there are detected foraminifer species not encountered below: *Arenobulimina senonica* (Voloshina), *Orbignyna variabilis* (d'Orbigny), *Globorotalites michelinianus* (d'Orbigny), and *Stensioeina exsculpta exsculpta* (Reuss). The latter is the index species of the corresponding foraminifer zone, to which we attribute this assemblage. The thickness is 21 m.

Bed 5 (depth range from 412 to 407 m): light greenish gray clayey limestones, displaying bioturbation, hard, with dense interlayers. The very impoverished foraminifer assemblage of the *Stensioeina exsculpta exsculpta* Zone was found at a depth of 411 m. The thickness is 5 m.

Bed 6 (depth range from 407 to 400 m): gray carbonate clay grading upward into dark-gray carbonate-free clay; the transition to the overlying noncarbonate sediments of the Nariman sequence is gradual. Scarce foraminifers of the *Stensioeina exsculpta exsculpta* Zone occur at a depth of 405 m. The thickness is 7 m.

Data on Well 502 elucidate the lithology of younger deposits. The following units are recognized here from the base upward (figure).

The Dubovka Sequence

Bed 1 (depth range from 300 to 290 m): white-gray chalklike limestones, hard, thick platy, intercalated with hard calcareous chalk; sediments contain the foraminifer assemblage of the *Stensioeina exsculpta exsculpta* Zone, including the index species, *Globorotalites michelinianus* (d'Orbigny), *Stensioeina granulata granulata* (Olbertz), *Gavelinella umbilicatula* (Mjatliuk), and *G. infrasantonica* (Balakhmatova). The thickness is 10 m.

Bed 2 (depth range from 290 to 285 m): light-gray marls, partly siliceous, dense and platy; *Ataxophragmium nautiloides* Vassilenko and *Stensioeina granulata perfecta* Koch show their first occurrence at the depth of 289 and 286 m, respectively. The thickness is 5 m.

Bed 3 (depth range from 285 to 280 m): light siliceous marls with interlayers of silica-free varieties; the transition to overlying deposits is gradual. The thickness is 5 m.

Bed 4 (depth range from 280 to 278 m): gray siliceous clayey marl; the foraminifer assemblage of the *Stensioeina exsculpta exsculpta* Zone with predominant *Stensioeina granulata granulata*, scarce *Eponides concinnus plana* Vassilenko, *Cibicidoides praeeriksdalensis* Vassilenko, and *Bolivinita eleyi* Cushman still occurs in the bed. The thickness is 2 m.

The Nariman Sequence

Bed 5 (depth range from 278 to 275 m): light-gray siliceous clay, slightly carbonate; at a depth of 277.5 m, the radiolarian assemblage of *Euchitonia santonica–Pseudoaulophacus floresensis* Zone was encountered. It includes *Acaeniotyle* aff. *diaphorogona* Foreman, *Archaeospongoprunum cortinaensis* Pessagno, *Cromyodruppa concentrica* Lipman, *Crucella cachensis* Pessagno, *Euchitonia santonica* Lipman, *Histiastrum aster* Lipman, *H. latum* Lipman, *Orbiculiforma vacaensis* Pessagno, *O. quadrata* Pessagno, *Patellula euessceei* Empson-Morin, *P. planoconvexa* (Pessagno), *Pentinastrum subbotinae* Lipman, *Praeconocaryomma californiaensis* Pessagno, *Pseudoaulophacus floresensis* Pessagno, *Pseudoaulophacus praefloresensis* Pessagno, *Rhopalastrum tumidum* Lipman, *Septinastrum dogeli* Gorbovetz, *Stylosphaera pusilla* Campbell et Clark, *Amphipyndax stocki* (Campbell et Clark), *Dictyomitra densicostata* Pessagno, *D. multicostata* Zittel, and *Xitus asymbatos* (Foreman). The thickness is 3 m.

Bed 6 (depth range from 275 to 270 m): dark-gray to black siliceous argillites with shelly jointing. The thickness is 5 m.

Bed 7 (depth range from 270 to 265 m): dark-gray to black argillites with brown spots, slightly calcareous. The thickness is 10 m.

Bed 8 (depth range from 265 to 260 m): dark-gray to black silty, carbonate argillites. The thickness is 5 m.

Bed 9 (depth range from 260 to 252 m): dark-gray and black argillites, somewhat silty, slightly micaceous, carbonate-free to slightly calcareous. The thickness is 8 m.

Bed 10 (depth range from 252 to 240 m): dark-gray and black somewhat silty clay, micaceous, with shelly jointing; at the depth of 248 m, the considerably impoverished radiolarian assemblage was found. It is represented by *Cromyodruppa concentrica* Lipman, *Histiastrum aster* Lipman, *H. latum* Lipman, *Rhopalastrum* *tumidum* Lipman, and *Dictyomitra densicostata* Pessagno. The thickness is 8 m.

Bed 11 (depth range from 240 to 233 m): dark-gray to black, dense clay, partially argillite-like. The thickness is 3 m.

Bed 12 (depth range from 223 to 210 m): dark-gray to black clayey micaceous siltstone. The thickness is 13 m.

Bed 13 (depth range from 210 to 207 m): gray, strongly micaceous silt, glauconitic, clayey, displaying a week bioturbation; fragments of small pelecypods were found at the top of the bed. The thickness is 3 m.

Bed 14 (depth range from 207 to 192 m): black and dark-gray silty micaceous argillite. The thickness is 15 m.

Bed 15 (depth range from 192 to 169 m): dark-gray to greenish silts, showing strong bioturbation, micaceous, with brown spots and glauconite nests. The thickness is 23 m.

The Zarya Sequence

Bed 16 (depth range from 169 to 156 m): dark-gray and black silts, siliceous, partly calcareous; the *Patellula planoconvexa–Amphibrachium mucronatum–Amphipyndax tylotus* radiolarian assemblage was encountered at the depth of 163 m. It consits of the following species: *Amphibrachium mucronatum* Lipman, *A. sibiricum* Gorbovetz, *Cromyodruppa concentrica* Lipman, *Histiastrum aster* Lipman, *H. latum* Lipman, *Patellula euessceei* Empson-Morin, *Patellula planoconvexa* (Pessagno), *Pentinastrum subbotinae* Lipman, *Porodiscus* aff. *cretaceous* Campbell et Clark, *Septinastrum dogeli* Gorbovetz, *Spongodiscus volgensis* Lipman, *Spongoprunum crassum* Lipman, *Amphipyndax tylotus* Foreman, *Dictyiomitra densicostata* Pessagno, *D. multicostata* Zittel, *Archaeodictyomitra* ex gr. *squinaboli* Pessagno, *Stichomitra cechena* Foreman, and *S. campi* (Campbell et Clark). The thickness is 13 m.

Bed 17 (depth range from 156 to 120 m): dark-gray, black, and greenish brown clays, dense, micaceous, silty in places, carbonate-free, massive or platy; the following agglutinated foraminifers were found at the depth of 153.5 m: *Rhabdammina* sp., *Bathysiphon* sp., *Rhizammina* sp., *Saccammina* sp., *Haplophragmoides* sp., *Ammobaculites* sp., and *Spiroplectammina* sp. Calcareous foraminifers *Dentalina* sp., *Nodosaria* sp., *Stylostomella?* sp., and young specimens of *Brotzenella monterelensis* (Marie), *Cibicidoides aktulagayensis* Vassilenko, and *C. voltzianus* (d'Orbigny) were identified there as well. The *Patellula planoconvexa–Amphibrachium mucronatum–Amphipyndax tylotus* radiolarian assemblage occurs up to the depth of 148 m. The thickness is 36 m.

Bed 18 (depth range from 120 to 118 m): gray and dark-gray to black siltstones, clayey (strongly clayey at the base), micaceous, carbonate-free, bearing dispersed coalified detritus. The thickness is 2 m.

Bed 19 (depth range from 118 to 106 m): dark-gray to greenish brown clay, micaceous, somewhat silty, carbonate-free. The thickness is 12 m.

The Bereslavka Sequence

Bed 20 (depth range from 106 to 99 m): dark-gray to black siltstone, with greenish brown spots, slightly micaceous, carbonate-free, clayey in places and displaying a week bioturbation. The thickness is 5 m.

Bed 21 (depth range from 99 to 90 m): dark-gray to black, slightly brownish silt, sandy, locally showing admixture of fine-grained quartz-glauconite sand; a layer with nests of glauconitic sand occurs at the base of the bed. The thickness is 9 m.

Bed 22 (depth range from 90 to 85 m): dark-gray, strongly micaceous silt, with local signs of bioturbation; the rock is carbonate-free. The thickness is 5 m.

The beds 20–22 (depth interval 104–85 m) yield an impoverished, poorly preserved radiolarian assemblage. It includes representatives of *Amphibrachium, Pentinastrum,* and *Septinastrum* genera associated with scarce nassellarians *Stichomitra campi* (Campbell et Clark) and *Theocampe animula* Gorbovetz.

The discussed sediments are overlaid by the 85-m-thick sequence of Neogene-Quaternary deposits.

BIOSTRATIGRAPHY

Foraminifers

Foraminifers are abundant in the sediments of the Dubovka sequence and occur in deposits of the Zarya sequence as well. The following assemblages were distinguished in the section from the base upward.

(1) The *Hedbergella holzli* assemblage (Dubovka sequence, Well 28, Bed 2, depth of 461 m) is characterized by predominance of planktonic *Hedbergella* forms, including *H. holzli* (Hagn et Zeil), *H. bornholmensis* Douglas, and *H. paradubia* Sigal, which associate with *Rugoglobigerina ordinaria* Subbotina. The assemblage is referred to the Early Turonian *Hedbergella holzli* Zone (Naidin *et al.*, 1984a, 1984b). Large accumulations of planktonic *Hedbergella* shells were recorded at the Cenomanian-Turonian boundary in the sections of Western Europe, Mediterranean, and Atlantic Ocean (Robaszynski, 1984; Robaszynski *et al.*, 1982).

(2) The *Gavelinella moniliformis* assemblage (Dubovka sequence, Well 28, Bed 2, depth of 458 m) was distinguished because of presence of the index species and *Arenobulimina presli* (Reuss) and *A. orbignyi* Brotzen characteristic of the Upper Turonian. A similar assemblage is characteristic of the *Gavelinella moniliformis* Zone of the lower upper Turonian in the Mangyshlak and Caspian region (Naidin *et al.*, 1984a, 1984b), whereas in the western Russian platform, this zone corresponds to the uppermost Turonian (Akimets *et al.*, 1991).

(3) The *Ataxophragmium nautiloides* assemblage (Dubovka sequence, Well 28, Bed 3, depth of 450–445 m) was distinguished because of presence of the index species and other forms typical of the *Ataxophragmium nautiloides* Zone. Its characteristic species are *Arenobulimina presli* (Reuss), *Marssonella* sp., *M. oxycona* (Reuss), *M. araksensis* Azizbekova, *Gyroidina nitida* (Reuss), *Eponides karsteni–concinna* Brotzen, and *Gavelinella kelleri* (Mjatliuk). In the eastern part of the European paleobiogeographical area (EPA), this zone corresponds to the Upper Turonian (Naidin *et al.*, 1984a, 1984b).

(4) The *Gavelinella praeinfrasantonica* assemblage (Dubovka sequence, Well 28, Bed 3, depth of 440 m) is recognized because of appearance of the index species, although forms of the previous assemblage still occur in sediments. The deposits of the zone are attributed to the early Coniacian in the east of the EPA (Naidin *et al.*, 1984a, 1984b).

(5) The *Stensioeina granulata granulata* assemblage (Dubovka sequence, Well 28, Bed 4, depths of 433 and 424 m) is characterized by the first occurrence of a series of forms, namely of the index species, *Ataxophragmium compactum* Brotzen, *Gyroidina turgida* (Hagenow), *Globorotaloides michelinianus* (Orbigny), *Osangularia whitei* (Brotzen), and *Gavelinella infrasantonica* (Balakhmatova). Moreover, *Gavelinella moniliformis* (Reuss), *Gyroidina nitida* (Reuss), and *Marssonella* representatives have their last occurrence at this level. The assemblage is referred to the synonymous zone, which is distinguished in the lower upper Coniacian of the Mangyshlak and eastern Caspian region (Naidin *et al.*, 1984a, 1984b). In Western Germany, the zone ranges throughout the Lower Coniacian (Koch, 1977). The first occurrence level of *Stensioeina granulata granulata* (Olbertz) and *Osangularia whitei* (Brotzen) is recorded in the mid-Coniacian deposits of the eastern EPA (Mangyshlak, Caspian and Volga regions, and Belarus), Western Germany, and France (Koch, 1977; Robaszynski and Amedro, 1980).

(6) The *Stensioeina exsculpta exsculpta–Stensioeina granulata perfecta* assemblage (Dubovka sequence, Well 28, Bed 4, depth of 418 m; Bed 5, depth of 411 m; Dubovka sequence, Well 502, Bed 1, depths of 300–290 m) is recognized as being the first occurrence of its index species. Its eponymous zone is recorded in the upper Coniacian and lower Santonian of western Kazakhstan and Western Germany (Naidin *et al.*, 1984a, 1984b; Koch, 1977). In the Dnieper–Donets depression and Belarus, the *Stensioeina exsculpta exsculpta* Zone corresponds to the lower part of the *Gavelinella infrasantonica* Zone and to the top of the *Gavelinella costulata* Zone, which range throughout the uppermost Coniacian and lowermost Santonian deposits (Grigelis *et al.*, 1980; Akimets *et al.*, 1991).

(7) The *Haplophragmoides–Spiroplectammina* beds (Zarya sequence, Well 502, Bed 17, depth of 153.5 m) were distinguished in the lower part of the Zarya sequence. They are characterized by a peculiar assemblage composed of agglutinated forms and scarce calcareous nodosariids and anomalinids, including *Brotzenella monterelensis* (Marie) and *Cibicidoides votzianus* (d'Orbigny), which are important in stratigraphic aspect and mark the lower part of the upper Campanian within the whole EPA (Naidin *et al.*, 1984b).

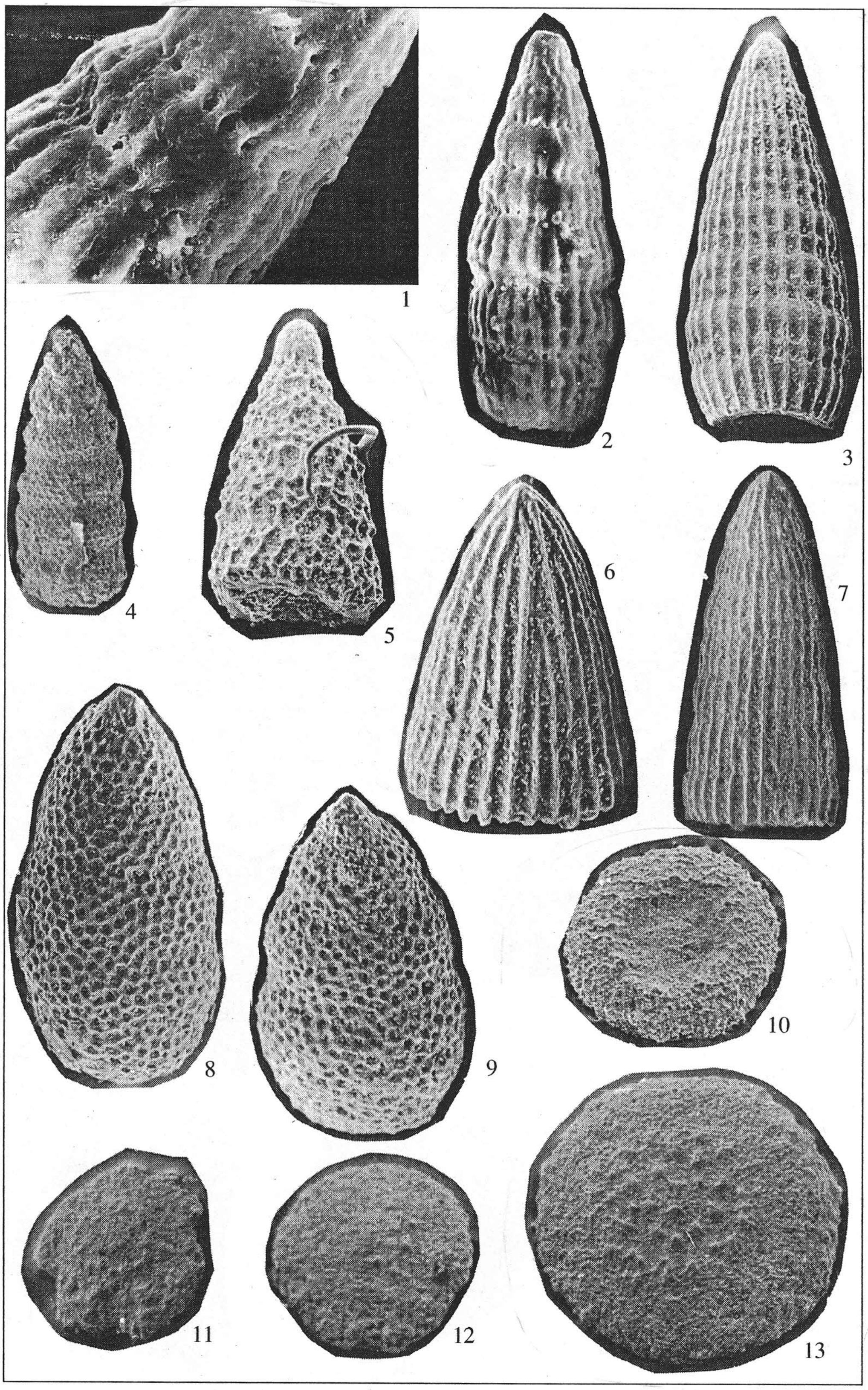
Radiolarians

Three radiolarian assemblages are distinguished.

(1) The *Euchitonia santonica–Pseudoaulophacus floresensis* assemblage (Nariman sequence, Well 502, Beds 5–9, depths of 277.5–250 m) is represented by *Acaeniotyle* aff. *diaphorogona* Foreman, *Archaeospongoprunum cortinaensis* Pessagno, *Cromyodruppa concentrica* Lipman, *Crucella cachensis* Pessagno, *Euchitonia santonica* Lipman, *Histiastrum aster* Lipman, *H. latum* Lipman, *Orbiculiforma vacaensis* Pessagno, *O. quadrata* Pessagno, *Patellula euessceei* Empson-Morin, *P. planoconvexa* (Pessagno), *Pentinastrum subbotinae* Lipman, *Praeconocaryomma californiaensis* Pessagno, *Pseudoaulophacus floresensis* Pessagno, *P. praefloresensis* Pessagno, *Rhopalastrum tumidum* Lipman, *Septinastrum dogeli* Gorbovetz, *Stylosphaera pusilla* Campbell et Clark, *Amphipyndax stocki* (Campbell et Clark), *Dictyomitra densicostata* Pessagno, *D. multicostata* Zittel, and *Xitus asymbatos* (Foreman) (Plate I–II).

Since sediments 12.5 m downward in the Dubovka section (Bed 1) contain the foraminifer assemblage of the *Stensioeina exsculpta exsculpta* Zone (the uppermost Coniacian–lowermost Santonian), the overlying *Euchitonia santonica–Pseudoaulophacus floresensis* radiolarian assemblage cannot be older than this level.

According to listed species, the assemblage under discussion is rather diverse and dominated by discoidal morphotypes. For instance, the representatives of *Histiastrum, Rhopalastrum*, and *Orbiculiforma* genera are most abundant. The assemblage includes species of a wide geographic ranges, such as, *Amphipyndax stocki, Dictyomitra densicostata, D. multicostata*, and *Xitus asymbatos*, which associate with forms that appeared in the Coniacian like *Orbiculiforma vacaensis*. However, some species cited by Lipman (1952) as characteristic of the Santonian in the Russian plate (*Euchitonia santonica, Histiastrum aster*, and *H. latum*), dominate in the assemblage. It is also notable that the assemblage in question has only one third of its species common with the Santonian radiolarians of the Ul'yanovsk Volga region (Bragina, 1987); these are *Histiastrum aster, Rhopalastrum tumidum, Septinastrum dogeli*, and *Dictyomitra densicostata*. The similarity is considerably higher at the generic level because both assemblages are characterized by different species of the same genera. It is of particular interest that *Spongoprunum articulatum*, characteristic and predominant in both Santonian



Plates I, II. Late Cretaceous radiolarians from the Volgograd Volga region.

Plate I. (1) *Dictyomitra densicostata* Pessagno, shell fragment, ×400; (2) *D. densicostata* Pessagno, ×200; (3) *D. multicostata* Zittel, ×200; (4) *Stichomitra cechena* Foreman, ×100; (5) *Amphipyndax tylotus* Foreman, ×200; (6, 7) *Dictyomitra* ex gr. *squinaboli* Pessagno: (6) ×300, (7) ×200; (8, 9) *Stichomitra campi* (Campbell et Clark), ×300; (10) *Orbiculiforma vacaensis* Pessagno, ×100; (11) *Patellula verteroensis* (Pessagno), ×100; (12, 13) *P. euessceei* Empson-Morin: (12) ×100, (13) ×200.

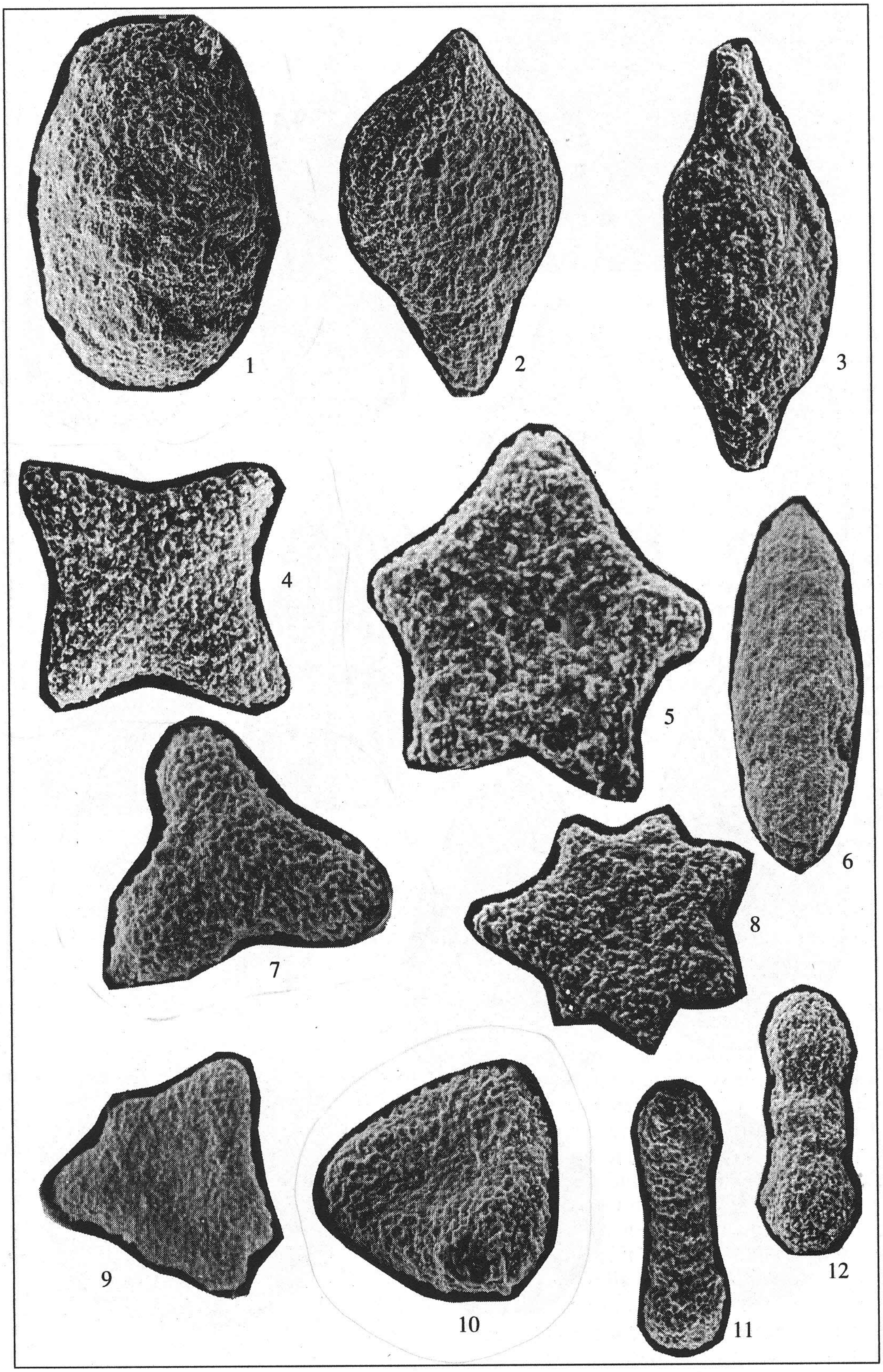


Plate II. (1) *Cromyodruppa concentrica* Lipman, ×200; (2) *Spongodiscus* sp., ×200; (3) *Spongoprunum crasum* Lipman, ×200; (4) *Histiastrum aster* Lipman, ×200; (5, 9) *Pentinastrum subbotinae* Lipman, ×200; (6) *Amphibrachium sibiricum* Gorbovetz, ×100; (7) *Rhopalastrum tumidum* Lipman, ×200; (8) *Septinastrum dogeli* Gorbovetz, ×100; (10) *Euchitonia santonica* Lipman, ×200; (11, 12) *Amphibrachium mucronatum* Lipman, ×100.

and Campanian deposits of the Ul'yanovsk region (Bragina, 1987), was not found in the studied assemblage. The difference may be a result of the lower stratigraphic position of the studied assemblage. Many its species (nearly a half) are also typical of the Santonian assemblage of the Penza region (Lipman, 1952). However, the Coniacian–Santonian assemblages from the Usa River region of the northern Russian plate (Amon, 1994), have only three species in common with the discussed assemblage, namely, *Cromyodruppa concentrica, Orbiculiforma quadrata*, and *O. vacaensis*. Amon distinguished the *Dictyomitra triara aspinosa–Pseudoaulophacus* sp. assemblage in the Santonian of the Volga region (Amon and De Wever, 1994). As he did not list all species of the assemblage, any comparison is impossible in this case. It is also relatively difficult to establish the relationships between the Coniacian–Santonian *Orbiculiforma quadrata–Crucella irwini* assemblage from the Khot'kovo Group of the Moscow region (Bragina, 1994) and the *Euchitonia santonica–Pseudoaulophacus floresensis* assemblage distinguished in this work. We can only state that almost all of the latter species occur in the Moscow region, however, the studied assemblage (Bragina, 1994) is much more impoverished. Moreover, the Moscow regional assemblages lack the dominant species unlike the discussed one. In the Moscow syneclise, Vishnevskaya and Kazintsova (1990) distinguished the Coniacian *Archaeospongoprunum bipartitum–A. triplum* and Santonian *Euchitonia santonica* assemblages. Eighty percent of species in these assemblages are present in all assemblages from the Moscow region (Bragina, 1994), and approximately a half of them is typical of the studied assemblages from the Volgograd region. It is interesting that a half of the *Euchitonia santonica–Pseudoaulophacus floresensis* assemblage is represented by species known and described from the Californian subtropical province (Foreman, 1968; Campbell and Clark, 1944; Pessagno, 1976). The studied assemblage also includes several unknown species that require the further description.

(2) The *Patellula planoconvexa–Amphibrachium mucronatum–Amphipyndax tylotus* assemblage (Zarya sequence, Well 502, beds 16–17, depths of 163–148 m) contains *Amphibrachium mucronatum* Lipman, *A. sibiricum* Gorbovetz, *Cromyodruppa concentrica* Lipman, *Histiastrum aster* Lipman, *H. latum* Lipman, *Patellula euessceei* Empson-Morin, *Pentinastrum subbotinae* Lipman, *P. planoconvexa* (Pessagno), *Porodiscus* aff. *cretaceous* Campbell et Clark, *Septinastrum dogeli* Gorbovetz, *Spongodiscus volgensis* Lipman, *Spongoprunum crassum* Lipman, *Amphipyndax tylotus* Foreman, *Archaeodictyomitra* ex gr. *squinaboli* Pessagno, *Dictyomitra densicostata* Pessagno, *D. multicostata* Zittel, *Stichomitra campi* (Campbell et Clark), *S. cechena* Foreman, *Theocampe animula* Gorbovetz, and includes almost all the species of the underlying *Euchitonia santonica–Pseudoaulophacus floresensis* assemblage. The assemblage is also distinct because of a high predominance of spongy forms. However, other species, namely the numerous representatives of *Amphibrachium* and *Spongoprunum* genera are abundant here. Another peculiarity of the assemblage is that some nassellarians, like *Stichomitra campi* and *Theocampe animula* described from the Campanian of West Siberia (Kozlova and Gorbovetz, 1966), are almost as abundant as the spongy forms. We should note in addition the presence of *Amphipyndax tylotus* unknown previously in the Russian plate. Its first finding is extremely important, as it is the zonal species in the late Campanian-Maastrichtian tropical assemblages (Sanfilippo and Riedel, 1985). The occurrence of *Amphibrachium* and *Spongoprunum* forms also indicates the Campanian age (Lipman, 1952) of the assemblage. Therefore, the majority of species of the assemblage is known from the Campanian. According to the stratigraphic range of the zonal species *Amphipyndax tylotus*, the age of the *Patellula planoconvexa–Amphibrachium mucronatum–Amphipyndax tylotus* assemblage should correspond the late Campanian. This conclusion is confirmed by the distribution of foraminifers of the *Brotzenella monterelensis* (Marie)–*Cibicidoides votzianus* (d'Orbigny) assemblage encountered at the same level. The comparison with the Campanian assemblage of the Ul'yanovsk region revealed only one third of species in common; these are *Amphibrachium mucronatum, Cromyodruppa concentrica, Histiastrum aster, H. latum, Dictyomitra densicostata*, and *D. multicostata*. The similarity with assemblages of the same age from West Siberia is higher. In this case, species in common (two thirds) are *Cromyodruppa concentrica, Histiastrum aster, H. latum, Porodiscus cretaceous, Pentinastrum subbotinae, Spongodiscus volgensis, Septinastrum dogeli, Amphibrachium mucronatum, A. sibiricum*, and *Theocampe animula*.

The analogues of the upper Campanian *Patellula planoconvexa–Amphibrachium mucronatum–Amphipyndax tylotus* assemblage are unknown in the Moscow region. The relationship between the younger *Archaeospongoprunum salumi–A. hueyi* assemblage from the Moscow region (Bragina, 1994) and the assemblage under consideration is relatively clear. The latter is obviously younger, as it contains *Amphipyndax tylotus* and coexisting numerous prunoids. Therefore, the *Archaeospongoprunum salumi–A. hueyi* assemblage from the Moscow region is not younger than the middle Campanian.

(3) The third assemblage is recorded in the depth interval of 104–85 m. It is characterized by predominance of discoid forms with a spongy skeleton, which are typical to the Upper Cretaceous in the Russian plate. These are species of genera *Amphibrachium, Pentinastrum*, and *Septinastrum*. Among nassellarians, only scarce *Stichomitra* and *Theocampe* forms were encountered (Plates I, II). Unfortunately, the poor preservation of microfossils and low taxonomic diversity suggest only rather wide Campanian–Maastrichtian range of the assemblage.

CONCLUSION

Main conclusions of this study are as follows.

(1) The radiolarian *Euchitonia santonica–Pseudoaulophacus floresensis* assemblage occurs in the Nariman sequence above the foraminiferal assemblage of the *Stensioeina exsculpta exsculpta* Zone. Thus, the radiolarian assemblage is of the late Coniacian–Santonian age.

(2) The radiolarian *Patellula planoconvexa–Amphibrachium mucronatum–Amphipyndax tylotus* assemblage found in the Zarya sequence at the occurrence level of foraminifers *Brotzenella monterelensis* and *Cibicidoides votzianus*, which are characteristic of the lower upper Campanian within the whole European paleobiogeographical area.

(3) In composition, the studied radiolarian and foraminiferal assemblages are similar to the Boreal (West Siberian) microfossil faunas. This suggests a past connection between the West Siberian and East European basins.

Reviewers I.A. Basov and V.S. Vishnevskaya

REFERENCES

Akimets, V.S., Ben'yamovskii, V.N., and Kopaevich, L.F., The Western Part of the European USSR and Western Kazakhstan, Upper Series, in *Prakticheskoe rukovodstvo po mikrofaune SSSR. Foraminifery mezozoya* (Guide to the USSR Microfauna: Mesozoic Foraminifers), Leningrad: Nedra, 1991, vol. 5, pp. 192–210.

Amon, E.O., A Review of Upper Cretaceous Biostratigraphy of the Polar Urals, in *Novye dannye po stratigrafii verkhnego paleozoya–nizhnego kainozoya Urala* (New Data on the Upper Paleozoic–Lower Cenozoic Stratigraphy of the Urals), Yekaterinburg: Ural. Otd. Ross. Akad. Nauk, 1994, pp. 109–138.

Amon, E.O. and De Wever, P., Upper Cretaceous Biostratigraphy of the Borders of the Ural Belt: Western Siberian and Eastern Volga–Ural Basins, in *Peri-Tethyan Platforms,* Paris, 1994, pp. 229–262.

Ben'yamovskii, V.N., Kopaevich, L.F., Akimets, V.S., *et al.*, Upper Cretaceous Foraminifer Stratigraphy of the Volga Region near Ul'yanovsk, *Izv. Akad. Nauk SSSR, Ser. Geol.*, 1988, no. 5, pp. 65–74.

Bragina, L.G., Abstracts of Papers, *VI konferentsiya molodykh uchenykh GIN AN SSSR* (VI Conf., Young Scientists of Geol. Inst. Akad. Nauk SSSR), Moscow: Nauka, 1987, pp. 1–7.

Bragina, L.G., Upper Cretaceous Radiolarians and Stratigraphy of the Khot'kovo Group of the Moscow Region, *Byull. Mosk. O-va. Ispyt. Prir., Otd. Geol.*, 1994, vol. 69, no. 2, pp. 91–100.

Campbell, A.S. and Clark, B.L., Radiolaria from Upper Cretaceous of Middle California, *Spec. Pap. Geol. Soc. Am.*, 1944, vol. 57, pp. 1–61.

Foreman, H., Upper Maastrichtian Radiolaria of California, *Paleontol. Spec. Pap.*, 1968, no. 3, pp. 1–82.

Grigelis, A.A., Akimets, V.S., and Lipnik, E.S., Phylogeneses of Benthic Foraminifers as a Basis of of the Upper Cretaceous Zonation (The East European Platform as an Example), *Vopr. Mikropaleontol.*, 1980, no. 23, pp. 145–159.

Koch, W., Stratigraphie der Oberkreide in Nordwestdeutschland (Pompeckjeche Scholle), part 2: Biostratigraphie der Oberkreide und Taxonomie von Foraminiferen, *Geol. Jahrb.*, 1977, no. 38, pp. 11–123.

Kozlova, G.E. and Gorbovets, A.N., Radiolarians from the Upper Cretaceous–Upper Eocene of the West Siberian Lowland, *Tr. Vses. Nauch.-Issled. Geol.-Razved. Inst.*, 1966, no. 248, pp. 1–158.

Lipman, R.Kh., Materials for Comprehensive Study of Late Cretaceous Radiolarians from the Russian Platform, in *Paleontologiya i stratigrafiya* (Paleontology and Stratigraphy), Moscow: Gos. Izd. Geol. Lit., 1952, pp. 24–45.

Naidin, D.P., Ben'yamovskii, V.N., and Kopaevich, L.F., *Metody izucheniya transgressii i regressii (na primere pozdnemelovykh basseinov Zapadnogo Kazakhstana)* (Investigation Methods of Trangressions and Regressions the Upper Cretaceous Basin of Western Kazakhstan as an Example), Moscow: Mosk. Univ., 1984a.

Naidin, D.P., Ben'yamovskii, V.N., and Kopaevich, L.F., The Upper Cretaceous Biostratigraphic Zonation of the European Paleobiogeographic Area, *Vestn. Mosk. Univ., Ser. 4, Geol.*, 1984b, no. 5, pp. 3–15.

Pessagno, E.A., Jr., Radiolarian Zonation and Stratigraphy of Upper Cretaceous Portion of the Great Valley Sequence, *Micropaleontol.*, 1976, no. 2, pp. 1–96.

Robaszynski, F., The Albian, Cenomanian and Turonian Stages in Their Type Regions, *Bull. Geol. Soc. Denmark,* 1984, vol. 33, pp. 191–198.

Robaszynski, F., Alcayde, G., Amedzo, F., *et al.*, Le Touronian de la Region-Type: Sinemurois et Touraine stratigraphie, biozonations, sedimentologie, *Bull. Centres Rech. Explor. Prod. EL-Aquitaine*, 1982, vol. 6, no. 1, pp. 119–225.

Robaszynski, F. and Amedro, F., Synthese biostratigraphique de L'Aptien au Santonien du Boulonnais a parties de sept groupes paleontologiques: foraminiferes, nannoplankton, dinoflagelless et macrofaunes, *Rev. Micropaleontol.*, 1980, vol. 22, no. 4, pp. 195–225.

Sanfilippo, A. and Riedel, W.R., Cretaceous Radiolaria, in *Plankton Stratigraphy,* Cambridge: Cambridge Univ., 1985, pp. 631–712.

Vishnevskaya, V.S. and Kazintsova, L.I., Cretaceous Radiolarians of the USSR, in *Radiolyarii v biostratigrafii* (Radiolarians in Biostratigraphy), Sverdlovsk: Ural. Otd. Akad. Nauk SSSR, 1990, pp. 44–58.