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Radiolarians from Upper Cretaceous Deposits, the Novodevich'e Section (Samara Oblast, Volga River Middle Courses)

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Abstract—Radiolarians from the Novodevich'e section, Samara oblast, are described. Two subdivisions of the section correspond to the 6.5-m-thick member of clay and chalk with Turonian–Coniacian benthic foraminifers and to the other member of intercalated opoka and clay beds, which are 6.8 m thick in total and yield benthic foraminifers of the upper Coniacian–Santonian in association with radiolarians. Of 41 radiolarian species, which have been identified, the most typical are *Cromyodruppa concentrica* Lipman, *Crucella aster* (Lipman), *C. cachensis* Pessagno, *C. latum* (Lipman), *Orbiculiforma monticelloensis* Pessagno, *O. quadrata* Pessagno, *Paronaella santonica* (Lipman), *P. tumida* (Lipman), *Patulibracchium ingens* (Lipman), *Pentinastrum subbotinae* Lipman, *Praeconocaryomma lipmanae* Pessagno, *P. universa* Pessagno, *Pseudoaulophacus lenticulatus* (White), *Triactoma compressa* (Squinabol), *Amphipyndax stocki* (Campbell et Clark), *Dictyomitra multicostata* Zittel, and *Xitus asymbatos* (Foreman). The late Coniacian–Santonian age of radiolarian assemblage is inferred based on coexisting radiolarians and on correlation with radiolarians characteristic of the Zagorsk Formation of the Moscow syneclise. As compared to radiolarian assemblages of the Moscow syneclise, which are taxonomically diverse and include many taxa known from California and bottom sediments of tropical oceanic regions, and to concurrent assemblages of the Urals and West Siberia, which are depleted in thermophilic species, the Late Cretaceous radiolarians from the Volga River middle courses are of a transitional taxonomic composition. It is plausible to conclude therefore that thermophilic taxa migrated into the East European sea from the west, whereas cryophilic forms characteristic of the West Siberian basin arrived from the east and northeast. Species originally identified by Lipman (1952) are revised and described anew.

Key words: Upper Cretaceous, stratigraphy, radiolarians, foraminifers, Volga River basin.

INTRODUCTION

Radiolarians from Upper Cretaceous (Santonian–Maastrichtian) deposits in middle courses of the Volga River have been described first by Lipman (1952) who studied core sections recovered by drilling in the east of the Penza oblast. Later on, they have been investigated in other sections of the region located near the Ul'yanovsk (Bragina, 1987), Saratov (Kazintseva, 2001), and between the Volga and Don rivers (Bragina *et al.*, 1999). These microfossils are of particular interest for the detailed subdivision and correlation of Upper Cretaceous (predominantly Santonian–Campanian) siliceous deposits, which, being widespread in the study region, rarely yield inoceramids and foraminifers, the main orthostratigraphic fossils of the Upper Cretaceous. Moreover, the Late Cretaceous radiolarians of the region essentially differ in diversity and taxonomic composition from radiolarian assemblages in bottom sediments of the World Ocean tropical zone, which have been used to elaborate the Upper Cretaceous radiolarian zonation, the only one that is sufficiently detailed and complete at present (Sanfilippo and Reidel, 1985). In addition, the Late Cretaceous radiolarians from the region under consideration are inadequately studied: they are lacking classical description and stratigraphic succession of their assemblages has not been analyzed. Accordingly, it is difficult to assess stratigraphic potential, paleofacies and paleoclimatic significance of this fossil group. Therefore, investigation of radiolarians is an actual problem for the Upper Cretaceous reference sections in middle courses of the Volga River.

METHODS

Radiolarians have been studies in clay samples (about 200 g in weight), which are more suitable for radiolarian analysis than opokas, in which radiolarian skeletons are significantly recrystallized because of the late diagenetic redistribution of silica. The collected samples have been disintegrated first in hydrogen peroxide (H_2O_2) and treated then in diluted acetic acid (CH_3COOH) in order to eliminate carbonate particles (remains of inoceramid prismatic layer). Radiolarians have been picked up from dry residues under binocular microscope and photographed under the scanning electron microscope Cambridge Stereoscan 600 at the Geological Institute, Russian Academy of Sciences. We are grateful to N.V. Gor'kova who performed the electron-microscopic research.

SECTION AND STRATIGRAPHIC SUCCESSION OF MICROFAUNAS

The sedimentary sequence studied near the Novodevich'e Village, Samara oblast (Fig. 1), have been selected earlier as an object for excursions of the International Geological Congress of 1984 (Adas *et al.*, 1984). Rocks of the sequence are perfectly exposed and yield abundant well-preserved radiolarians in association with informative benthic foraminifers (preliminary identified by V.N. Beniamovskii). Sediments for radiolarian analysis have been sampled in 1989 by N.Yu. Bragin, and E.Yu. Baraboshkin collected additional samples bearing foraminifers in 2000. The section description presented below is based on field observations of 1989 (Fig. 2).

The Albian deposits at the base of the section are represented by dark gray to black silty clay with rare black phosphorite nodules. The overlying Upper Cretaceous sequence is composed of the following beds.

Bed 1: greenish black medium-grained glauconite sand with redeposited pebbles of Albian phosphorite; sand discordantly overlies the eroded surface of Albian clay (0.2 to 0.4 m thick);

Bed 2: light gray calcareous–sandy clay displaying gradual transitions to underlying and overlying sediments (0.2 m thick); beds 1 and 2 yield foraminifers of the middle Turonian *Gavelinella moniliformis* Zone (Akimets *et al.*, 1991);

Bed 3: grayish compact sandy chalk with blocky jointing (about 6 m thick); in the interval from 0 to 2 m above the bed base, there is established a succession of the upper Turonian *Gavelinella moniliformis* and *Gavelinella praeinfrasantonica* foraminiferal zones (Akimets *et al.*, 1991). The level of 2 m above the base corresponds to an erosion surface, above which foraminifers of the upper Coniacian *Gavelinella thalmanni* Zone and index subspecies *Stensioeina exculpta exculpta* of the upper Coniacian–lower Santonian have been encountered (Akimets *et al.*, 1991);

Bed 4: light gray sandy opoka; the bed base corresponds to an erosion surface with phosphorite and chalk pebbles (0.3 m thick);

Bed 5: light colored, greenish gray marly clay; the bed is flaggy (0.4 m thick);

Bed 6: massive opoka of the same coloration; the bed is 0.6 m thick;

Bed 7: clay like that of Bed 5 (0.5 m thick); Sample 21 from the bed yielded radiolarians *Cromyodruppa concentrica* Lipman, *Crucella aster* (Lipman), *C. irwini* Pessagno, *C. latum* (Lipman), *Dispongotripus triangularis* (Squinabol), *Orbiculiforma impressa* (Lipman), *O. quadrata* Pessagno, *O. persenex* Pessagno, *O. vacaensis* Pessagno, *Paronaella tumida* (Lipman), *Pentinastrum subbotinae* Lipman, *Pseudoaulophacus praefloresensis* Pessagno, *Triactoma compressa* (Squinabol), *Vitorfus brustolensis* (Squinabol), and *Dictyomitra densicostata* Pessagno;

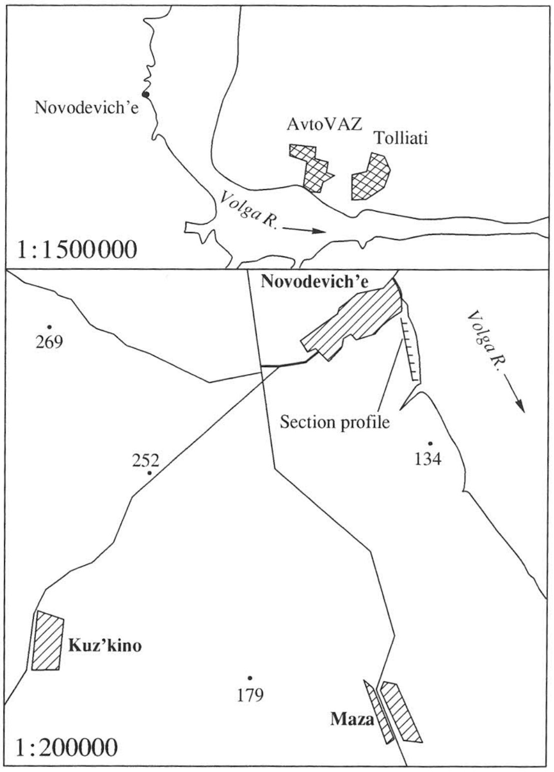


Fig. 1. Locality of Upper Cretaceous deposits near the Novodevich'e Village (figures denote altitudes in meters).

Bed 8: opoka like that of Bed 6 (1 m thick); beds 4 to 8 bear foraminifer species *Neoflabellina suturalis* of the upper Coniacian–lower Santonian (Akimets *et al.*, 1991);

Bed 9: clay like that of Bed 5 (0.5 m thick); radiolarians identified in Sample 22 from this bed are *Acaeniotyle umbilicata* (Rust), *Archaeospongoprunum bipartitum* Pessagno, *A. cortinaensis* Pessagno, *A. hueyi* Pessagno, *Crucella aster* (Lipman), *C. cachensis* Pessagno, *C. latum* (Lipman), *C. messinae* Pessagno, *Cromyodruppa concentrica* Lipman, *Orbiculiforma monticelloensis* Pessagno, *Patulibracchium* aff. *P. petroleumensis* Pessagno, *P. ingens* (Lipman), *Paronaella santonica* (Lipman), *P. tumida* (Lipman), *Pentinastrum subbotinae* Lipman, *Phaseliforma* sp. cf. *P. subcarinata* Pessagno, *Praeconocaryomma californiaensis* Pessagno, *P. lipmanae* Pessagno, *P. universa* Pessagno, *Pseudoaulophacus pargueraensis* Pessagno, *Spongopyle insolita* group Kozlova, *Amphipyndax stocki* (Campbell et Clark), *Archaeodictyomitra* sp. ex gr. *A. squinaboli* Pessagno, *Dictyomitra densicostata* Pessagno, *D. multicostata* (Zittel), *Stichomitra cechena* Foreman, and *Xitus asymbatos* (Foreman).

Bed 10: opoka like that of Bed 6; the bed is 0.6 m thick;

Bed 11: clay like that of Bed 5 (0.3 m thick), radiolarians identified in Sample 23 from the bed are *Acaeniotyle umbilicata* (Rust), *Crucella aster* (Lipman),

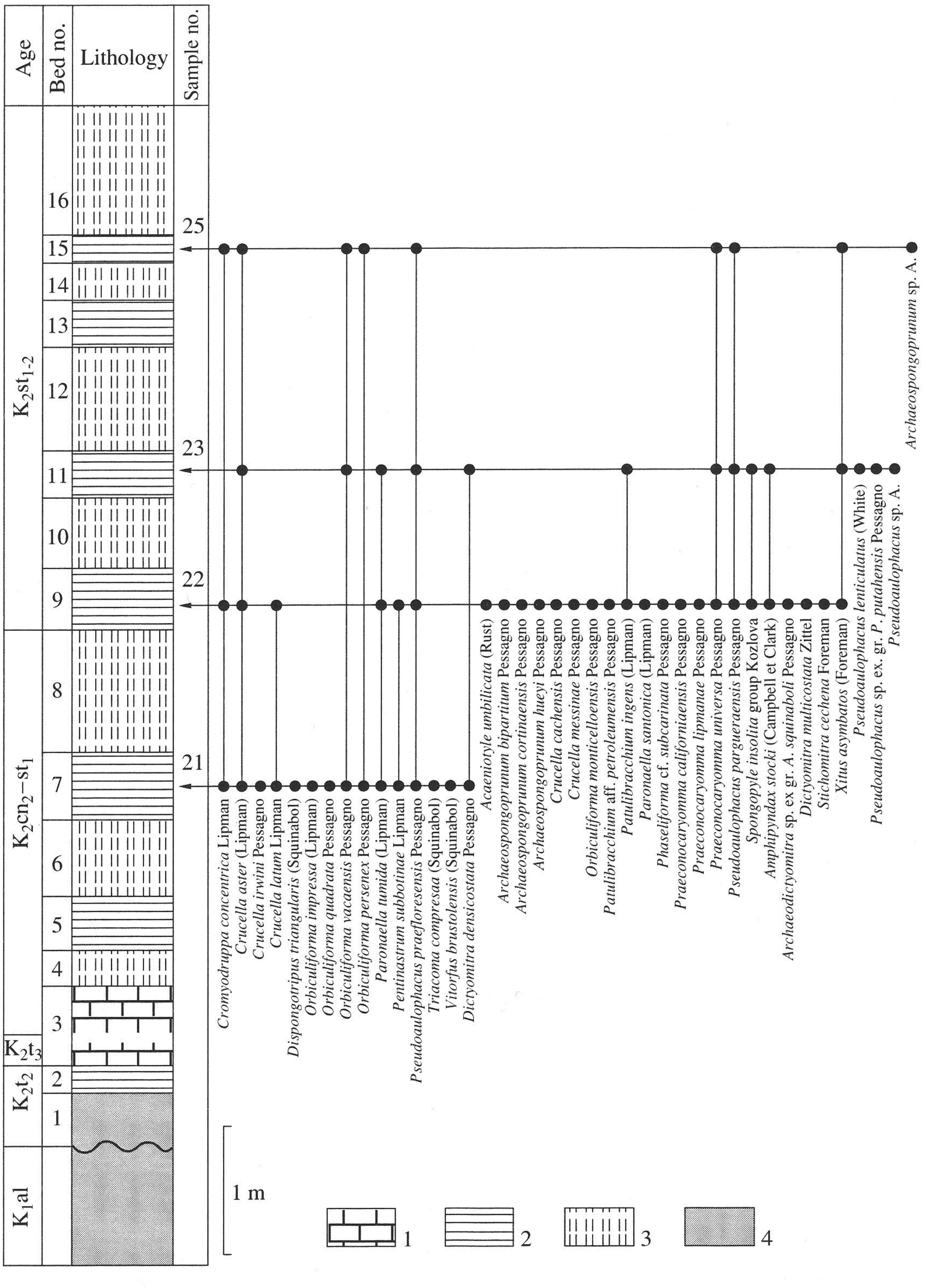


Fig. 2. Stratigraphic ranges of radiolarians in the Novodevich'e section of Upper Cretaceous deposits (Bed 3 is shown out of scale): (1) chalk-like limestone; (2) clay; (3) opoka; (4) sand.

Orbiculiforma vacaensis Pessagno, *Paronaella tumida* (Lipman), *Patulibracchium ingens* (Lipman), *Praeconocaryomma universe* Pessagno, *Pseudoaulophacus lenticulatus* (White), *Pseudoaulophacus pargueraensis* Pessagno, *Ps. praefloresensis* Pessagno, *Ps.* sp. ex gr. *Ps. putahensis* Pessagno, *Ps.* sp. A, *Spongopyle insolita* group Kozlova, *Amphipyndax stocki* (Campbell et Clark), *Dictyomitra densicostata* Pessagno, and *Xitus asymbatos* (Foreman).

Bed 12: opoka like that of Bed 6 (0.8 m thick);

Bed 13: clay like that of Bed 5 (0.3 m thick);

Bed 14: opoka like that of Bed 6 (0.3 m thick);

Bed 15: clay like that of Bed 5 (0.2 m thick); the bed (Sample 25) yields radiolarians *Archaeospongoprunum* sp. A, *Alievium* sp. A, *Cromyodruppa concentrica* Lipman, *Crucella aster* (Lipman), *Orbiculiforma persenex* Pessagno, *O. vacaensis* Pessagno, *Praeconocaryomma universa* Pessagno, *Pseudoaulophacus pargueraensis* Pessagno, *P. praefloresensis* Pessagno, and *Xitus asymbatos* (Foreman). In addition, beds 9–15 yield foraminifers *Stensioeina exculpta gracilis* of the terminal lower–upper Santonian (Akimets *et al.*, 1991).

Bed 16: opoka like that of Bed 6, the apparent thickness is 1 m.

After the next unexposed interval, there are low hills with detritus of gray and white quartz sandstones (Paleogene?). The presumable thickness of sandstones is 3 to 4 m.

RESULTS AND DISCUSSION

Radiolarians found at several level within the upper Coniacian–Santonian interval of the sequence represent in fact one diverse assemblage (Fig. 2) consisting of 41 species. These are *Acaeniotyle umbilicata* (Rust), *Alievium* sp. A, *Archaeospongoprunum bipartitum* Pessagno, *A. cortinaensis* Pessagno, *A. hueyi* Pessagno, *Archaeospongoprunum* sp. A, *Cromyodruppa concentrica* Lipman, *Crucella aster* (Lipman), *C. cachensis* Pessagno, *C. irwini* Pessagno, *C. latum* (Lipman), *C. messinae* Pessagno, *Dispongotripus triangularis* (Squinabol), *Orbiculiforma impressa* (Lipman), *O. monticelloensis* Pessagno, *O. quadrata* Pessagno, *O. persenex* Pessagno, *O. vacaensis* Pessagno, *Paronaella santonica* (Lipman), *P. tumida* (Lipman), *Patulibracchium ingens* (Lipman), *P.* aff. *P. petroleumensis* Pessagno, *Pentinastrum subbotinae* Lipman, *Phaseliforma* sp. cf. *P. subcarinata* Pessagno, *Praeconocaryomma californiaensis* Pessagno, *Pr. lipmanae* Pessagno, *Pr. universa* Pessagno, *Pseudoaulophacus lenticulatus* (White), *Ps. pargueraensis* Pessagno, *Ps. praefloresensis* Pessagno, *Ps.* sp. ex gr. *Ps. putahensis* Pessagno, *Ps.* sp. A, *Spongopyle insolita* group Kozlova, *Triactoma compressa* (Squinabol), *Vitorfus brustolensis* (Squinabol), *Amphipyndax stocki* (Campbell et Clark), *Archaeodictyomitra* sp. ex gr. *A. squinaboli* Pessagno, *Dictyomitra densicostata* Pessagno, *D. multicostata Zittel, Stichomitra cechena* Foreman, and *Xitus asymbatos* (Foreman). Radiolarians are most diverse in Sample 22 (Bed 9), but all the species from this level are of a broad stratigraphic range.

Fifteen of the listed species have been originally described in California (Campbell and Clark, 1944; Pessagno, 1971, 1972, 1976), and many of them are of a wide geographic range. *Archaeospongoprunum bipartitum* Pessagno and *Orbiculiforma quadrata* Pessagno are known from Coniacian deposits of California (Pessagno, 1976), but in the Russian platform (e.g., in Moscow region) they are common in Santonian beds as well (Bragina, 1994). Species *Archaeospongoprunum cortinaensis* Pessagno, *Triactoma compressa* (Squinabol), and *Vitorfus brustolensis* (Squinabol) are characteristic of Cenomanian and Turonian sediments of the Tethyan region (Bragina, 1999; 2001; O'Dogherty, 1994; Salvini and Marcucci Passerini, 1998), although we do not exclude their occurrence in younger deposits, because the Coniacian–Santonian interval is insufficiently studied in Mediterranean areas. Such species as *Acaeniotyle umbilicata* (Rust), *Crucella latum* (Lipman), *Pseudoaulophacus lenticulatus* (White), *Amphipyndax stocki* (Campbell et Clark), *Dictyomitra multicostata* Zittel, and *Xitus asymbatos* (Foreman) occur worldwide in Cenomanian–Campanian strata. *Cromyodruppa concentrica* Lipman, *Paronaella santonica* (Lipman), *P. tumida* (Lipman), *Patulibracchium ingens* (Lipman), and *Pentinastrum subbotinae* Lipman are widespread in Coniacian–Campanian deposits of the Russian platform (Bragina, 1994; Bragina *et al.*, 1999; Vishnevskaya, 1987; Lipman, 1952; Olfer'ev *et al.*, 2000) and West Siberia (Kozlova and Gorbovets, 1966). The above data on distribution of radiolarians suggest the Coniacian–Santonian age of the assemblage, but coexisting foraminifers restrict it by the late Coniacian–Santonian time span.

It is interesting to compare the established assemblage with concurrent radiolarian faunas from Saratov and Ul'yanovsk areas of the Volga River basin. Kazintsova (2001) distinguished previously the early and late Santonian assemblages of radiolarians. Our assemblage includes six species characteristic of her early Santonian assemblage: *Cromyodruppa concentrica* Lipman, *Crucella aster* (Lipman), *Paronaella tumida* (Lipman), *Pseudoaulophacus lenticulatus* (White), *Amphipyndax stocki* (Campbell et Clark), and *Dictyomitra densicostata* Pessagno. Fourteen taxa from our assemblage represent species in common with her late Santonian assemblage. These are *Archaeospongoprunum bipartitum* Pessagno, *A. cortinaensis* Pessagno, *Cromyodruppa concentrica* Lipman, *Crucella aster* (Lipman), *C. latum* (Lipman), *Orbiculiforma monticelloensis* Pessagno, *O. persenex* Pessagno, *O. vacaensis* Pessagno, *Paronaella santonica* (Lipman), *P. tumida* (Lipman), *Pseudoaulophacus lenticulatus* (White), *Amphipyndax stocki* (Campbell et Clark), *Dictyomitra densicostata* Pessagno, and *D. multicostata* Zittel. The concurrent assemblage of the Ul'yanovsk area (Bragina, 1987) includes nearly all the species of the Samara assemblage except for *Dispongotripus triangularis* (Squinabol), *Phaseliforma* sp. cf. *P. subcarinata* Pessagno, *Ps.* ex gr. *Ps. putahensis* Pessagno, *Ps.* sp. A, *Triactoma compressa* (Squinabol), and *Vitorfus brustolensis* (Squinabol). Accordingly it is safe to conclude that the late Coniacian–Santonian radiolarian assemblages from different areas in middle courses of the Volga River are close to each other in taxonomic composition.

A comparison with concurrent or nearly concurrent assemblages of the Moscow region (Bragina, 1994) and Vladimir area (Olfer'ev *et al.*, 2000) is also interesting.

The assemblage from the Zagorsk Formation of the Moscow region includes 22 species in common with the assemblage of the Novodevich'e section. These are *Archaeospongoprunum bipartitum* Pessagno, *Cromyodruppa concentrica* Lipman, *Crucella aster* (Lipman), *C. irwini* Pessagno, *C. latum* (Lipman), *Orbiculiforma quadrata* Pessagno, *O. persenex* Pessagno, *O. vacaensis* Pessagno, *Paronaella santonica* (Lipman), *P. tumida* (Lipman), *Patulibracchium ingens* (Lipman), *Pentinastrum subbotinae* Lipman, *Praeconocaryomma californiaensis* Pessagno, *Pf. lipmanae* Pessagno, *Pr. universa* Pessagno, *Pseudoaulophacus praefloresensis* Pessagno, *Spongopyle insolita* group Kozlova, *Amphipyndax stocki* (Campbell et Clark), *Dictyomitra densicostata* Pessagno, *D. multicostata* Zittel, *Stichomitra cechena* Foreman, and *Xitus asymbatos* (Foreman). It is remarkable therewith that the assemblage from Moscow region is lacking two species of a wide geographic range: *Archaeospongoprunum cortinaensis* Pessagno and *Vitorfus brustolensis* (Squinabol). On the other hand, *Pseudoaulophacus floresensis* Pessagno, *Stylosphaera pusilla* Campbell et Clark, *Cryptamphorella conara* (Foreman), and *Tricolocapsa granti* Campbell et Clark, which are the widespread Late Cretaceous species known in Moscow region, have not been encountered in the Novodevich'e section. In general, the assemblage of Moscow region is more diverse and includes a greater number of species, which are characteristic of warm-water basins.

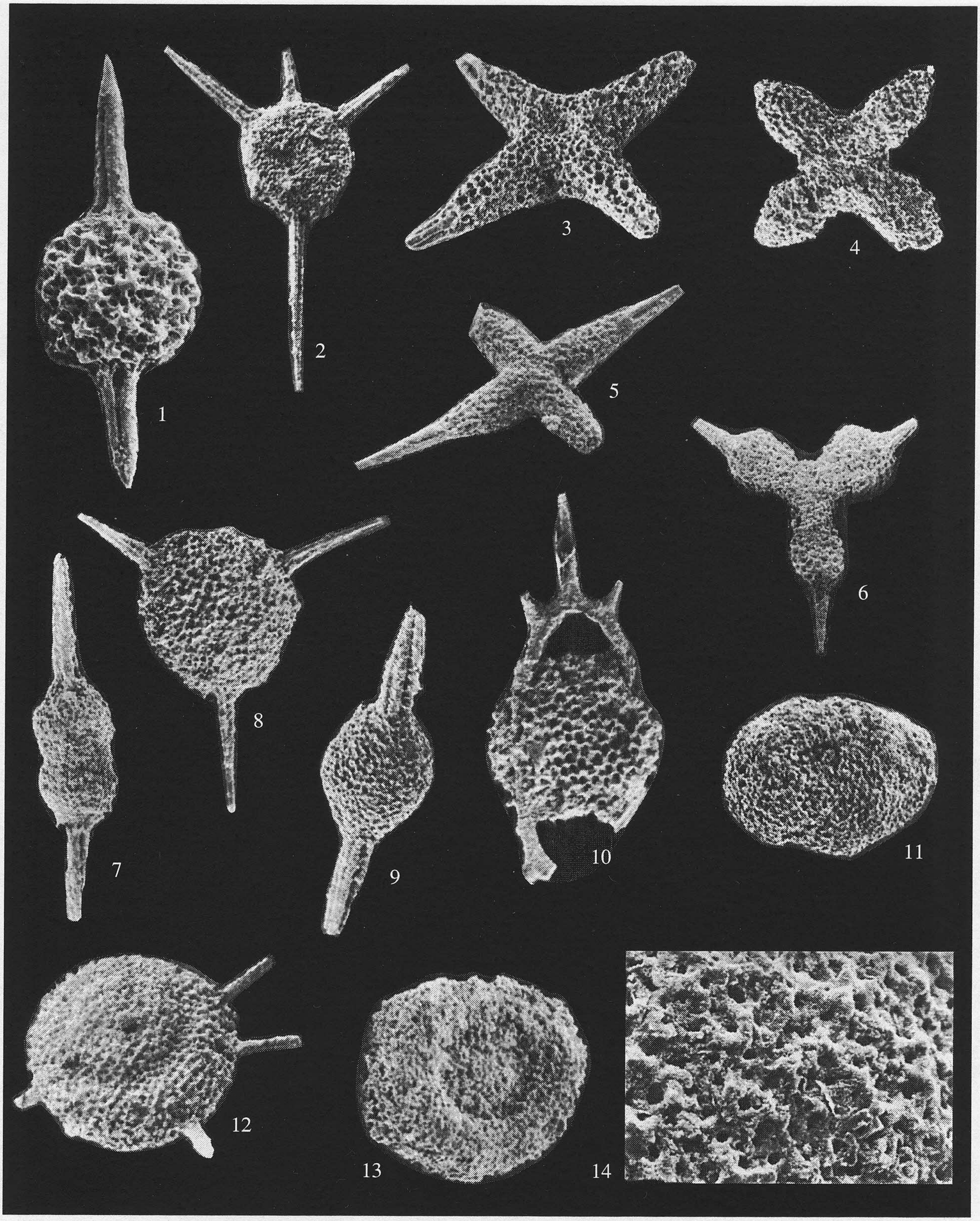
Comparing the assemblages of the Vladimir area and Novodevich'e section, we established nine species in common. These are *Archaeospongoprunum bipartitum* Pessagno, *Cromyodruppa concentrica* Lipman, *Orbiculiforma quadrata* Pessagno, *O. persenex* Pessagno, *O. vacaensis* Pessagno, *Paronaella tumida* Lipman, *Crucella aster* (Lipman), *C. latum* (Lipman), and *Xitus asymbatos* (Foreman). We suspect that the assemblage of Vladimir area just appears to be less diverse, because radiolarians are preserved here not as well as in the Moscow region.

Seven species in common established by comparison with Santonian assemblages from southern areas east of the Urals are as follows: *Archaeospongoprunum bipartitum* Pessagno, *Cromyodruppa concentrica* Lipman, *Crucella aster* (Lipman), *C. latum* (Lipman), *Praeconocaryomma universa* Pessagno, *Pseudoaulophacus lenticulatus* (White), and *Dictyomitra multicostata* Zittel. Assemblages from areas situated westward of the sub-Polar and northern Urals (Amon, 2000) include only two species occurring in the studied section (*Amphipyndax stocki* (Campbell et Clark) and *Dictyomitra multicostata* Zittel). It is remarkable as well that several species characteristic in general of the West Siberian radiolarians are missing from the assemblage of the Novodevich'e section. These are *Crucella tumeniensis* Lipman, *Porodiscus vulgaris* Lipman, *Spongotripus morenoensis* Campbell et Clark, *Stylotrochus dolichacanthus* (Lipman), and *Theocampe animula* (Kozlova and Gorbovets, 1966).

CONCLUSION

The late Coniacian–Santonian radiolarian assemblage of the Novodevich'e section is well correlative with concurrent assemblages of the Ul'yanovsk, Moscow, and Vladimir areas. Distinctions between these assemblages are suitable for the subsequent paleoclimatic and paleogeographic reconstructions. For instance, it is clear that the studied assemblage is transitional in taxonomic composition, connecting the assemblages of the Moscow syneclise, which are taxonomically diverse (Bragina, 1994), including many taxa known from California (Pessagno, 1976) and from bottom sediments of tropical oceanic regions (Sanfilippo and Riedel, 1985), and of the Urals and West Siberia, which are depleted in thermophilic species. Factors responsible for this can be found in peculiarities of the Late Cretaceous epicontinental seas of Eastern Europe and West Siberia and in their connections between each other and with adjacent sea basins. The West Siberian sea was undoubtedly well connected with the Arctic Ocean at that time but weakly communicated with basins of the Turan plate. This situation determined specific taxonomic compositions of radiolarian assemblages in West Siberia and nearby areas of the Urals, which are regarded as characteristic of the Boreal realm (Amon, 2000; Vishnevskaya, 2001). The East European basin could be connected with the West Siberian sea via straits that crossed the central Urals and Pai-Khoi Ridge (Amon and De Wever, 1994). Via a narrow meridional strait along the western flank of the Urals, it could be connected with Arctic cold waters, which penetrated to the middle stream area of the Volga River. Connections between the Tethys and East and West European seas were broad, favorable for ingression of warm waters into southern and western areas of the latter. Such an ingression was likely responsible for the relatively warm-water affinity of radiolarian assemblages of the Moscow syneclise and for a transitional status of radiolarians characterizing sections in middle courses of the Volga River.

Some species of Late Cretaceous radiolarians, which were described by Lipman as long ago as in the 1950s and currently need in revision, are described anew in the paleontological section of the work. Abilities of electronic microscopy have been used to improve morphological characterization of these species. Their systematics is specified with due account for all the semi-centennial changes in taxonomy of radiolarians.



Plates I–II. Late Coniacian–Santonian radiolarians from the Novodevich'e section, Samara oblast.

Plate I. (1) *Acaeniotyle umbilicata* (Rust), Sample 22, ×150; (2) *Dispongotripus triangularis* (Squinabol), Sample 21, ×80; (3) *Crucella cachensis* Pessagno, Sample 22, ×150; (4) *Crucella aster* (Lipman), Sample 21, ×150; (5) *Crucella messinae* Pessagno, Sample 22, ×150; (6) *Paronaella santonica* (Lipman), Sample 22, ×120; (7) *Archaeospongoprunum bipartitum* Pessagno, Sample 22, ×150; (8, 9) *Archaeospongoprunum cortinaensis* Pessagno, Sample 22, ×80 (8) and ×150 (9); (10) *Vitorfus brustolensis* (Squinabol), Sample 21, ×200; (11, 14) *Phaseliforma* cf. sp. *P. subcarinata* Pessagno, Sample 22, general view, ×150 (11) and perforation style of outer wall, ×800 (14); (12) *Pseudoaulophacus lenticulatus* (White), Sample 23, ×150; (13) *Orbiculiforma monticelloensis* Pessagno, Sample 22, ×150.

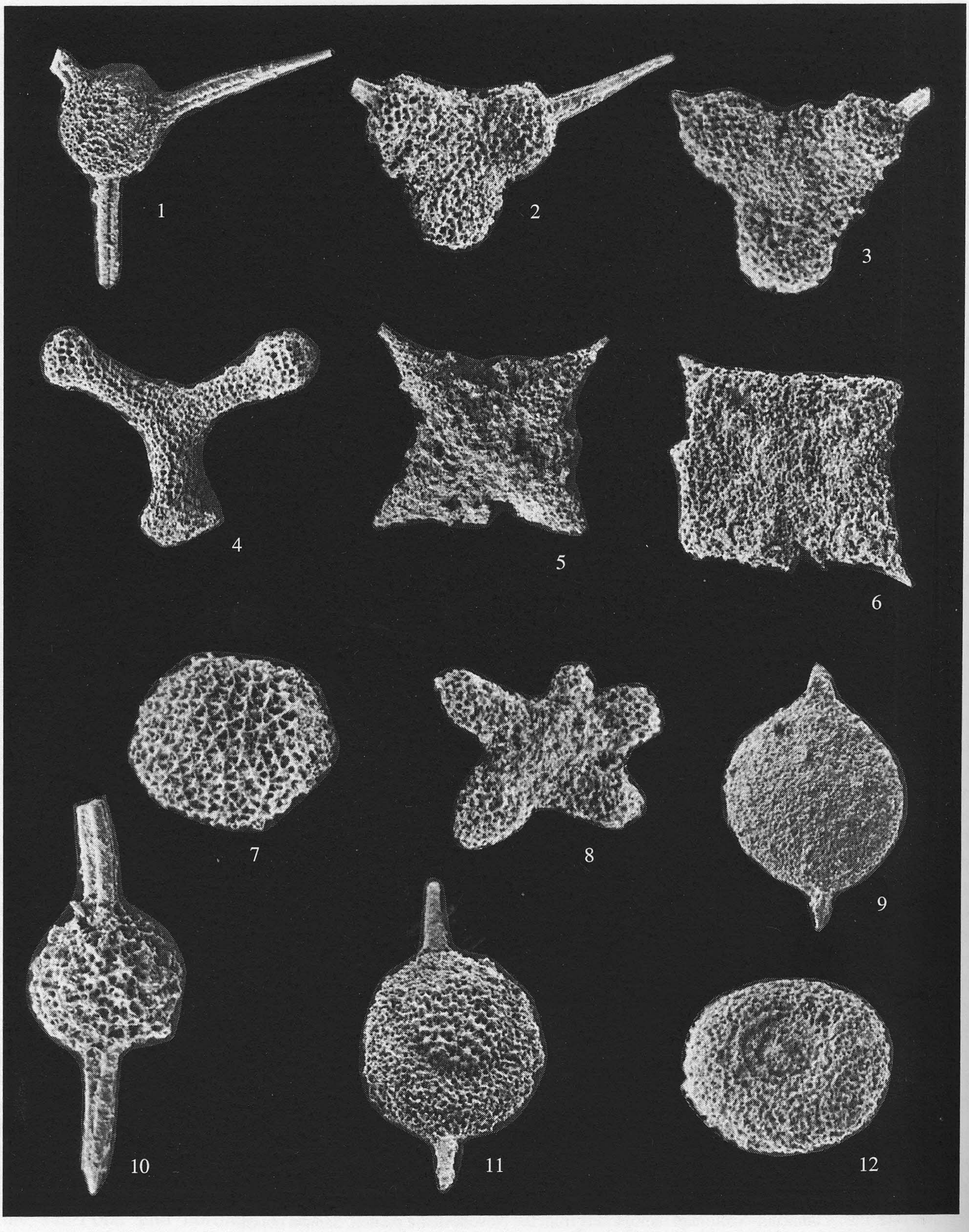


Plate II. (1) *Triactoma compressa* (Squinabol), Sample 21, ×80; (2, 3) *Paronaella tumida* (Lipman), Sample 21, ×150, (2) and ×140, (3); (4) *Patulibracchium ingens* (Lipman), Sample 22, ×65; (5, 6) *Crucella latum* (Lipman), from samples 21 (5) and 22 (6), ×100 in both figs.; (7) *Alievium* sp. A, Sample 25, ×150; (8) *Pentinastrum subbotinae* Lipman, Sample 22, ×100; (9) *Archaeospongoprunum* sp. A, Sample 25, ×150; (10) *Acaeniotyle umbilicata* (Rust), Sample 22, ×150; (11) *Pseudoaulophacus* sp. A, Sample 23, ×150; (12) *Orbiculiforma vacaensis* Pessagno, Sample 23, ×150.

PALEONTOLOGICAL DESCRIPTIONS

Family Hagiastridae Riedel, 1971

Subfamily Hagiastrinae Riedel, 1967, emend. Pessagno, 1971

Genus *Crucella* Pessagno, 1971

Crucella aster (Lipman, 1952)

Plate I, Fig. 4

Histiastrum aster: Lipman, 1952, p. 35, Plate II, figs. 6, 7; 1962, p. 300, Plate II, fig. 5; Kozlova and Gorbovets, 1966, p. 84, Plate III, fig. 9; Amon, 2000, p. 51, Plate VI, fig. 15; Vishnevskaya, 2001, Plate 115, fig. 6

Crucella aster: Kazintsova and Olfer'ev, 1997, Plate I, fig. 1 (nomen nudum).

Holotype: no.16/28, collection no. 6999, F.N. Chernyshev Central Geological Museum; Kuznetsk locality, Penza oblast, Santonian (Russian plate).

Description. Tests are medium-sized, with arms of quadrangular radiation. Central capsule of the test is not elevated. Each of the arms proximally broad is narrowing toward distal end that is terminated by a massive spine. The test surface is irregularly perforated by rounded-polygonal pores.

Dimensions. Two neighboring spine ends are 247 to 437 μm away from each other, spines are 152 to 57 μm long and 65 to 95 μm thick at maximum. Terminal needles are 20 to 60 μm long.

Remarks. Kazintsova and Olfer'ev (1997) attributed the species to the genus *Crucella*, but they did publish its paleontological description.

Distribution: worldwide, terminal upper Albian–Campanian.

Material: dozens of specimens.

Crucella latum (Lipman, 1960)

Plate II, figs. 5, 6

Histiastrum latum: Lipman *et al.*, 1960, p. 130, Plate XXIX, figs. 7, 8; Bragina, 1994, Fig. 1, fig. 9; Amon, 2000, p. 51, Plate VI, fig. 17; Vishnevskaya, 2001, p. 163, Plate 114, fig. 9.

Holotype: no. 56/3, collection no. 7767, Central Geological Museum, St. Petersburg (Plate XXIX, figs. 7, 8); West Siberia, lower part of the lower radiolarian sequence, Borehole 1-P; Santonian–Campanian.

Description. Medium-sized tests are quadrangular in plane. The test surface is irregularly perforated by rounded-polygonal pores. Apical spines are massive and long, usually round in cross-section.

Dimensions. Tests are 180 to 300 μm long, and needles are as long as 30–70 μm.

Comparison. Spines of irregular shape differ *Crucella latum* (Lipman, 1960) from *Crucella espartoensis* Pessagno (Pessagno, 1971).

Distribution: worldwide, terminal upper Albian–Campanian.

Material: dozens of specimens.

Genus *Paronaella* Pessagno, 1971

Paronaella santonica (Lipman, 1952)

Plate I, fig. 6

Euchitonia santonica: Lipman, 1952, p. 34, Plate II, fig. 3; Vishnevskaya, 2001, p. 162, Plate 114, fig. 11.

Holotype: no. 16/42, collection no. 6999, F.N. Chernyshev Central Geological Museum; the Kuznetsk site of Penza oblast, Santonian (Russian plate).

Description. Discoid skeletons are subtriangular in plane. Three short arms are facing vertices of equilateral (or isosceles) triangle. Being swollen, the arms are wider in plane than central region. Thick apical spines are frequently long, faceted near the base and conical at distal ends. Their length is 1.5–2 times greater than the thickest part. Arms are spongy inside. The internal part of central capsule is of annulate structure. External surface is irregularly perforated by minute pores of rounded polygonal shape. Patagium that is frequently preserved extends over arms concealing the spine basal ends.

Dimensions. Tests are 255–270 and 200–250 μm in diameter with and without spines, respectively; spines are 30 to 70 μm long.

Comparison. In distinction from *Paronaella venadoensis* Pessagno (Pessagno, 1971), tests have no byspines on radial spines, their arms are more swollen and perforations are smaller in diameter.

Distribution: Coniacian–Campanian of the Russian plate and West Siberia.

Material: 24 specimens.

Paronaella tumida (Lipman, 1952)

Plate II, fig. 2, 3

Rhopalastrum tumidum: Lipman, 1952, p. 37, Plate II, fig. 13; Bragina, 1994, Fig. 1, fig. 11

Holotype: no. 16/43, collection no. 6999, F.N. Chernyshev Central Geological Museum; Kuznetsk locality of Penza oblast., Santonian (Russian plate).

Description. Large discoid skeletons are subtriangular in plane. Three arms radiating toward vertices of equilateral triangle are very short. Central region is equal in size to basal diameters of arms. Small central tholus is insignificantly elevated. Arms are wider than central region, considerably swollen and rounded in shape. Apical spines are thick, frequently long, faceted near their base and conical at distal ends. Their length is almost equal in size to the thickest part diameter. Arms are spongy inside. The internal part of central region is of indistinct annulate structure. External surface is irregularly perforated by minute close-spaced pores of rounded polygonal shape. Patagium is often developed over the test surface and spine basal ends.

Dimensions. Skeletons are 240–270 μm in diameter, arms are 120–150 μm long and 95–110 μm wide,

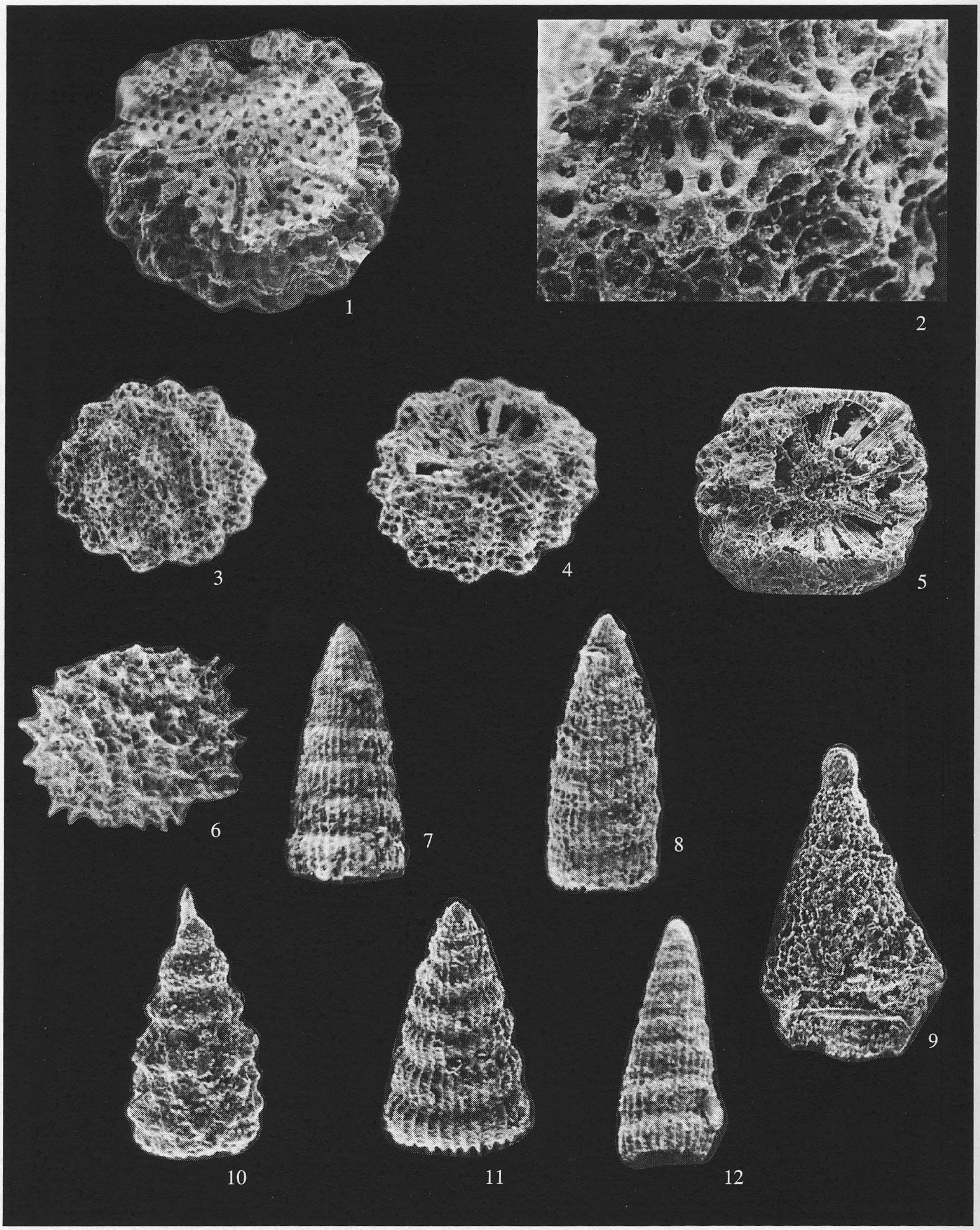


Plate III. (1–5) *Praeconocaryomma universa* Pessagno from samples 22, ×100 (1), 25, ×150 (3), 23, ×150 (4, 5), and details of perforations in test shown in fig. 4, ×600 (2); (6) *Praeconocaryomma lipmanae* Pessagno, Sample 22, ×150; (7, 8) *Archaeodictyomitra* sp. ex gr. *A squinaboli* Pessagno, Sample 22, ×150; (9) *Amphipyndax stocki* (Campbell et Clark), Sample 22, ×250; (10) *Xitus asymbatos* (Foreman), Sample 23, ×150; (11) *Dictyomitra multicostata* Zittel, Sample 22, ×150; (12) *Dictyomitra densicostata* Pessagno, Sample 22, ×120.

spines are 40–80 μm long, and pores range from 8 to 12 μm in diameter.

Comparison. In distinction from other species of the genus, arms of *Paronaella tumida* (Lipman, 1952) are swollen and rounded in plane. Shorter radial spines of specific shape differ the described species from *P. santonica* (Lipman).

Distribution: Coniacian–Campanian of the Russian plate and West Siberia.

Material: dozens of specimens.

Genus *Patulibracchium* Pessagno, 1971

Patulibracchium ingens (Lipman, 1952)

Plate II, fig. 4

Rhopalastrum ingens: Lipman, 1952, p. 37, Plate II, fig. 13 *Patulibracchium inaequalum*: Pessagno, 1971, p. 33, pi. 4, figs. 3-6; pi. 5, fig. 1

Holotype: no. 26/28, collection no. 6999, F.N. Chernyshev Central Geological Museum; Kuznetsk locality of Penza oblast, Santonian (Russian plate).

Description. Large tests have three arms, one of which can be sometimes longer than other arms. Central, slightly elevated region is approximately equal in size to the arm basal diameter. Arms are almost equally wide at proximal ends. In some specimens, wider sagittate terminations are characteristic of two longer arms, while in the others they characterize the shorter arm. In their widest part, sagittate terminations are swollen. Toward the distal end crowned sometimes by a short spine, arm walls converge. Brachiopyle is most distinct in the short arm. Test surface is perforated by round to subquadrangular pores, which can be arranged into rows oriented along the arm. At the junction point of several pores, skeleton can be decorated by small low hemispherical or conical tubercles. Pentagonal to hexagonal arrangement of pores is characteristic of the arm sagittate terminations.

Dimensions. Shorter and longer arms are170–200 and 600–500 μm long, respectively.

Comparison. In distinction from *P. teslaensis* Pessagno (Pessagno,1971), arms of the described species are oriented toward vertices of equilateral but not isosceles triangle.

Distribution: Cenomanian of California, Coniacian–Campanian of the Russian plate, upper Cenomanian *Triactoma parva–Patulibracchium ingens* Beds and lower Turonian and *Alievium superbum* Zone of the Crimea Mountains.

Material: 17 specimens.

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