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# Malacofauna of the Lower Cambrian Bystraya Formation of Eastern Transbaikalia

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**Abstract**—A monographic description of mollusks from the Lower Cambrian Bystraya Formation of Eastern Transbaikalia is presented for the first time. The mollusk assemblage includes ten species of nine genera; the following six species are new: *Miroconulus sinitsae* sp. nov., *Anuliconus tannuelliformis* sp. nov., *Parailsanella sayutinae* sp. nov., *Stenotheca transbaikalica* sp. nov., *Anabarella tshitaensis* sp. nov., and *Mellopegma uslonica* sp. nov. The taxonomic composition of the assemblage is similar to that of the Late Atdabanian–Botomian of South Australia and Mongolia.

## INTRODUCTION

Small shelly fossils (SSF) in the Lower Cambrian deposits of Transbaikalia were first discovered more than 20 years ago. However, there are no publications with complete monographic descriptions of this fauna, and only a few papers focused on particular taxonomic groups exist, i.e., on brachiopods (Ushatinskaya, 1988), bradoriids (Melnikova, 1988), and chancelloriids (Vassiljeva and Sayutina, 1988). In addition, one mollusk species from the Lower Cambrian of Transbaikalia, which was also recorded in Mongolia, was described by Zhegallo in a monograph on the biostratigraphy and fauna of the Lower Cambrian of Mongolia (Esakova and Zhegallo, 1996).

## MATERIAL

The rock samples studied were collected by S.M. Sinitsa (Chita Polytechnic University, Chita) and T.A. Sayutina (Paleontological Institute, Moscow) during field work in 1982–1985 and were passed to the Laboratory of Ancient Organisms of the Paleontological Institute of the Russian Academy of Sciences (PIN) for study. The samples of carbonate rocks were dissolved using the standard technique in 8–10% acetic acid. Shells and internal molds were examined using a scanning electron microscope (CamScan).

## STRATIGRAPHIC POSITION

In Eastern Transbaikalia Lower Cambrian deposits occur in two regions, i.e., the Kodar–Udokan structure-facies zone (Upper Kalar Graben) in the north and the Argun' structure-facies zone (Pakhomov and Barabasheva, 1990) in the southwest. In the Argun' River Region, in the Gazimurovskii Zavod District, Knyazev (1962, pp. 12, 24) established the Bystraya Group (after the Bystraya River), which is composed of three units, i.e., Kadainskaya, Uslon, and Georgievka formations. Later, the Bystraya Group was reevaluated as a formation with three subunits (Pakhomov, 1995).

The stratigraphic studies and interpretation of geological structure in the southern Argun' River Region are severely hampered by inadequate outcropping of rock, dissociation of exposures, complicated tectonic structure, and considerable facies variability of Precambrian and Lower Paleozoic strata (Knyazev, 1962; Pakhomov, 1995). As a result, rather contradictory data on the structure, thickness, and nomenclature of some stratigraphic units are present in the literature (Kozyrenko, 1956; Knyazev, 1962; Pakhomov, 1990, 1995; Pakhomov and Barabasheva, 1990).

According to the recent stratigraphic scheme (Pakhomov, 1995), the Bystraya Formation (syn.: Bystraya Group, Georgievka Formation) of the Argun' Group is subdivided into three subformations. The 620-m-thick lower subformation is represented by gray dolostone with thin interbeds of limestone at the base; the 500-m-thick middle subformation is composed of dark gray limestone or, more rarely, of dolostone with interbeds of clayish shale with phosphorites; and the 1500-m-thick upper subformation is represented by light gray massive dolostone with interbeds of quartz sandstones, argillites, clayish shales, and marls. The lower subformation contains algal remains and stromatolites. Trilobites, archaeocyathans, and diverse small shelly fossils (brachiopods, bradoriids, mollusks, and problematics) are known from the middle subformation. The upper subformation contains trilobites, algae, and stromatolites.

The Bystraya Formation is dated to the Tommotian–Botomian (Pakhomov, 1995) on faunal evidence (archaeocyathans, trilobites, and SSF). The formation

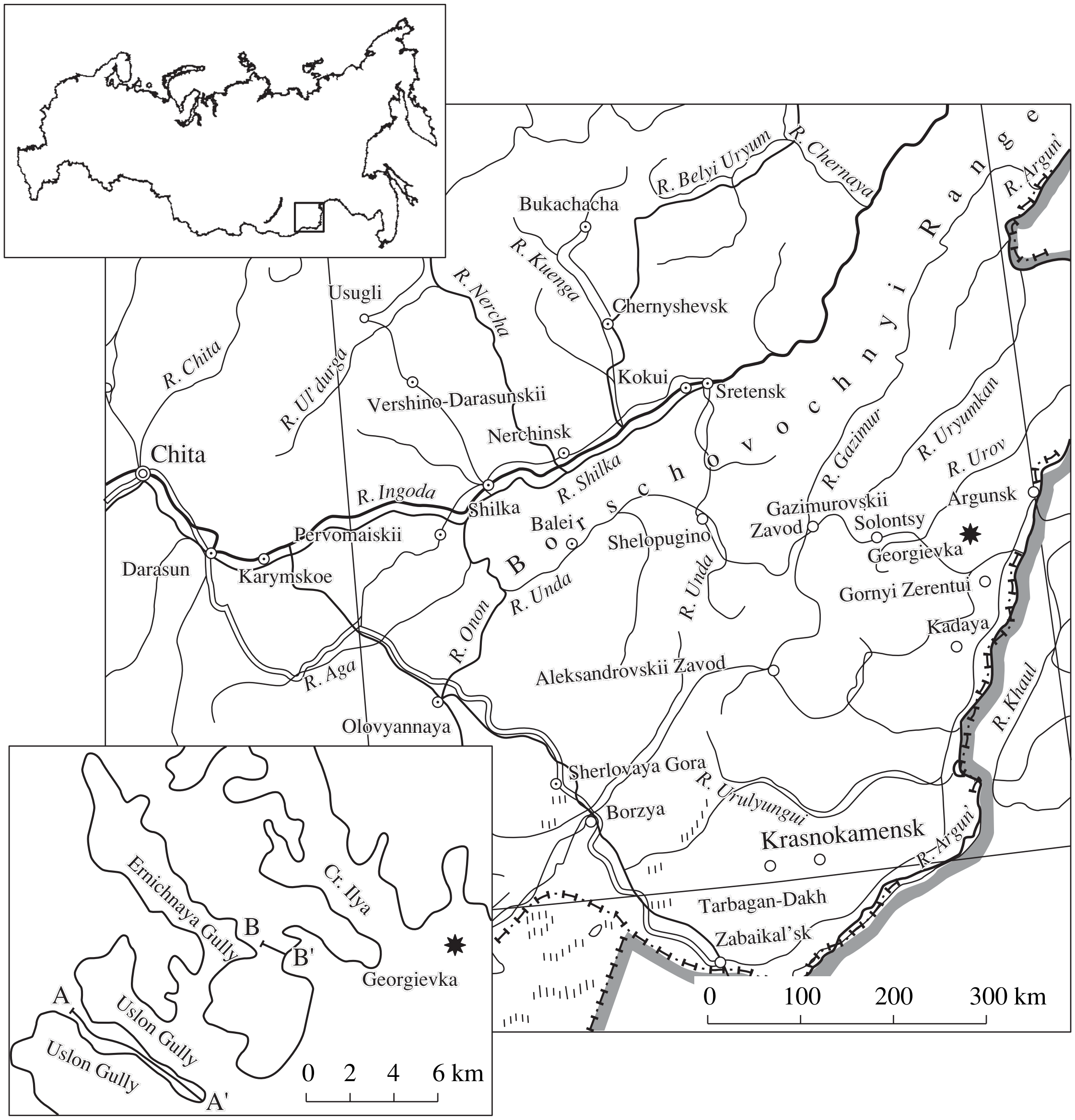



**Fig. 1.** Location map of studied Lower Cambrian sections of Eastern Transbaikalia. Abbreviations: (AA') Uslon Section; (BB') "Archaeocyathan Hill" Locality.

is underlain by the Precambrian Beletui Formation and overlain by the Ernichnaya Formation of probably Toyonian age. The mollusk assemblage under discussion comes from the middle subformation of the Bystraya Formation. Judging from the archaeocyathans and trilobites finds typical for the Kameshki and Sanashtyk-Gol horizons of the Altai–Sayan Standard, its age was estimated by V.V. Latin and L.N. Repina as Late Atdabanian–Botomian (Knyazev, 1962).

The most complete section of the formation (Georgievka Lectostratotype) is situated in the Nerchinskii Zavod District near the village of Georgievka (Fig. 1). In this place, the Bystraya Formation is represented by intercalation of rock members, in which dolostone or limestone varieties dominate (Pavlenko, 1984a,[1] 1984b[2]).

The rocks of the Bystraya Formation are exposed by the arterial trench along the watershed of the northwestern spurs of the Uslon Gully (Fig. 2). More than

[1] Pavlenko Yu.V., Georgievskii lektostratotip bystrinskoi svity Vostochnogo Zabaikalya [Georgievka Lectostratotype of the Bystraya Formation in Eastern Transbaikalia], in *Materials to the Report 1982–1984 of the Phosphate Group of the Experimental-Methodical Expedition of PGO Chita-Geologiya*. Chita, 1984a.

[2] Pavlenko Yu.V., Geologicheskii plan i stratigraficheskaya kolonka po kanave 01 (uch. Uslon) [Geological Plan and Stratigraphical Section along the Trench no. 01 (Uslon Sector)] in *Materials to the Report 1982–1984 of the Phosphate Group of the Experimental-Methodical Expedition of PGO Chita-Geologiya*. Chita, 1984b.

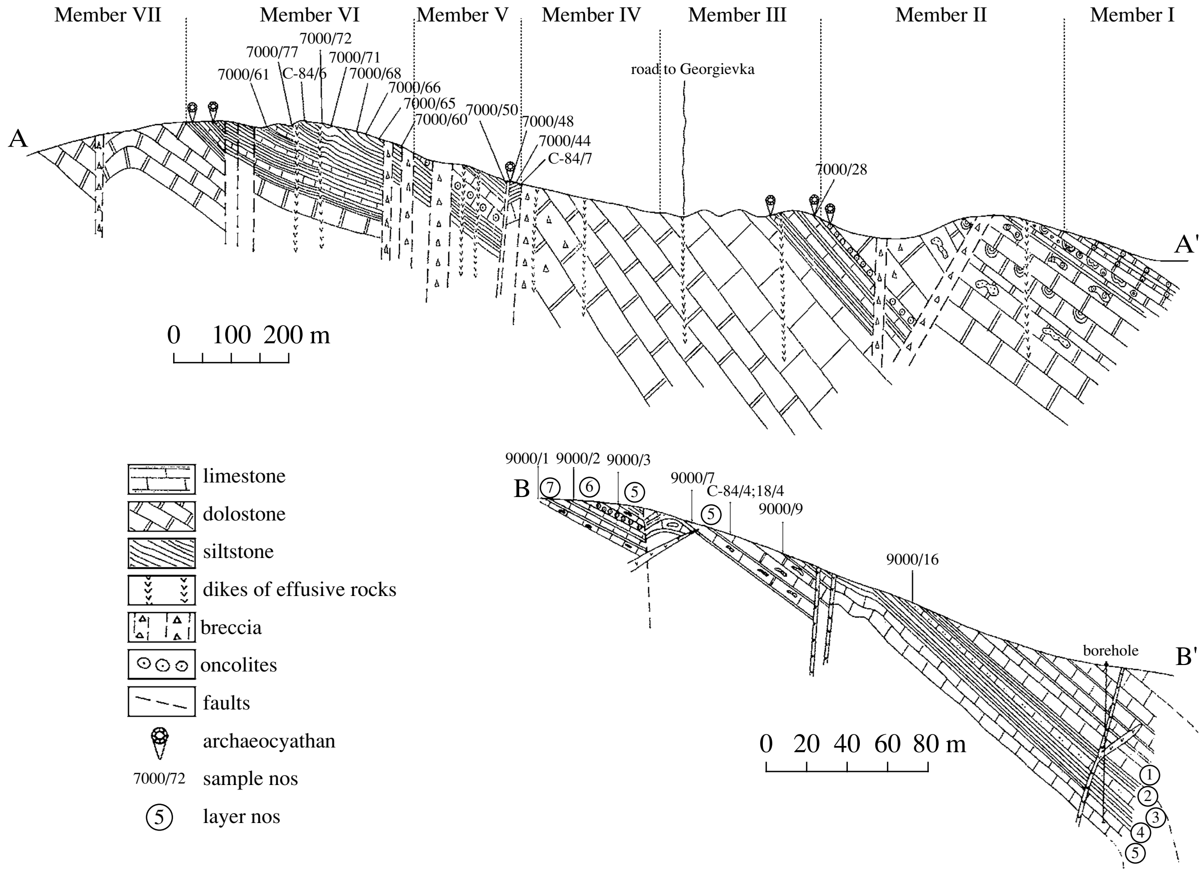



**Fig. 2.** Stratigraphic sections of the Bystraya Formation (drawings by S.M. Sinitsa). Abbreviations: (AA') Uslon Section (inverted bedding); (BB') "Archaeocyathan Hill" Locality.

100 rock samples were collected from the trench for microfaunal study. In addition, the archaeocyathan remains were found at several levels of the section, i.e., *Nochoroiocyathus kruzini* (Vor.), *Thalamocyathus georgiensis* (Latin), *Denaecyathus biporosus* Zhur., *Tumulifungia* sp., *Erismacoscinus* sp., *Mikhnocyathus zolaensis* Maslov, and *Usloncyathus miculus* Fonin. In spite of the considerable number of endemic species within the archaeocyathan assemblage, its generic composition suggests a Late Atdabanian–Botomian age for that part of the Bystraya Formation (Debrenne *et al.*, 1989).

The locality "Archaeocyathan Hill" is situated nearby (Fig. 2) and was also sampled. Mollusk remains were found in both sections in 20 of more than 100 rock samples that were collected.

## ANALYSIS OF THE MOLLUSK ASSEMBLAGE

The mollusk assemblage from the studied deposits is represented by ten species of nine genera. Four species, i.e., *Parailsanella lata* Parkh., *Yochelcionella crassa* Zheg., *Pelagiella adunca* Miss., and *Pojetaia runnegari* Jell are known from Lower Cambrian strata of many localities throughout the world. *Pelagiella adunca* is widely distributed in the Atdabanian and Botomian stages of the Siberian Platform and Altai–Sayan fold belt. *Pojetaia runnegari* is present in the Upper Atdabanian–Botomian of Australia, China, Mongolia, and the eastern part of Germany. *Parailsanella lata* was described from the Upper Atdabanian–Botomian of South Australia, while *Yochelcionella crassa* occurs in the Upper Atdabanian–Botomian of Mongolia. The other six species of the assemblage, i.e., *Miroconulus sinitsae* sp. nov., *Anuliconus tannuelliformis* sp. nov., *Parailsanella sayutinae* sp. nov., *Stenotheca transbaikalica* sp. nov., *Anabarella tshitaensis* sp. nov., and *Mellopegma uslonica* sp. nov., are described here and, at the present state of knowledge, are apparently endemics of Eastern Transbaikalia. The occurrence of the genera of these new species is given in the Species Composition sections of corresponding taxa.

The stratigraphic range of mollusk species and genera from the middle member of the Bystraya Formation suggests the Late Atdabanian–Botomian age of the assemblage. On the basis of the species distribution within the stratigraphic section (Fig. 3), we can conclude that the Atdabanian–Botomian boundary runs through Member VI of the Uslon Section. The species of stenothecid family, i.e., *Stenotheca transbaikalica* sp. nov., *Mellopegma uslonica* sp. nov., and *Anabarella*

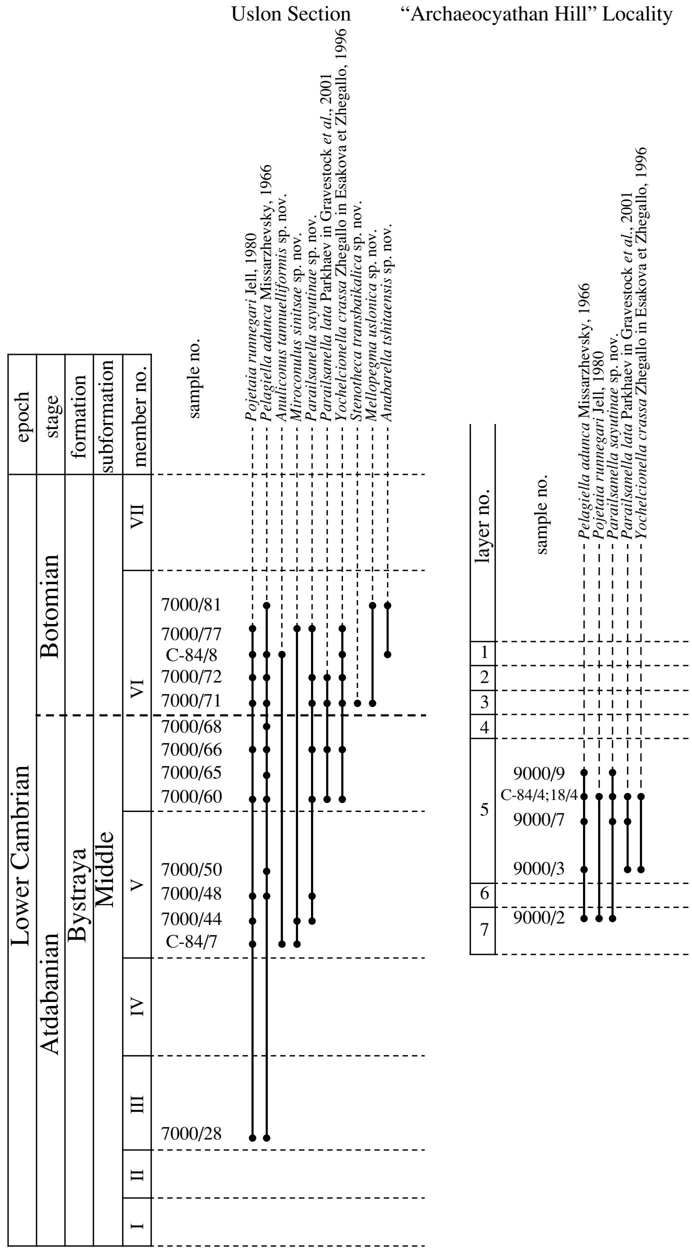



**Fig. 3.** Mollusks distribution within the studied sections of the Bystraya Formation of Eastern Transbaikalia (Uslon Section and "Archaeocyathan Hill" Locality).

*tshitaensis* sp. nov., appear at this level, starting from sample no. 7000/71 and higher up the section. The middle part of the "Archaeocyathan Hill" section, which is characterized by mollusk remains, can be correlated with Member V and the lowermost part of Member VI of the Uslon Section; and hence is, probably, Late Atdabanian.

From a biogeographic perspective, the Atdabanian–Botomian mollusk assemblage of Eastern Transbaikalia is most similar to coeval mollusk faunas of South Australia and Mongolia. Mollusks of 29 genera are present in the Atdabanian–Botomian of South Australia (Gravestock *et al.*, 2001, p. 135). Except for the genus *Mellopegma*, the other eight genera from the Bystraya Formation are present in the uppermost Atdabanian and Botomian of South Australia. The assemblage of the Bystraya Formation differs more considerably from the Mongolian assemblage of the *Parailsanella dzhargalantica* Zone (Esakova and Zhegallo, 1996). It yielded no species of *Khairkhania, Oelandiella, Obtusoconus, Igorella, Ilsanella* and *Aldanella* but yielded species of *Pelagiella, Miroconulus, Anuliconus, Stenotheca* and *Anabarella*, which are unknown in the Botomian of Mongolia. However, both regions have four genera in common, i.e., *Parailsanella, Mellopegma, Yochel-*

*cionella* and *Pojetaia*, and the latter two genera are represented by the same species, i.e., *Y. crassa* and *P. runnegari*.

The mollusks found in the Bystraya Formation of Eastern Transbaikalia are described below. The composition and synonymy of the previously established genera and species are revised and completed, the generic diagnoses are emended. In the other cases, the results of the latest taxonomic revision of the mentioned taxa (Gravestock *et al.*, 2001) are used. The pelecypod species *Pojetaia runnegari* Jell, 1980,[3] which has been repeatedly described in the literature (Jell, 1980; Runnegar and Bentley, 1983; He and Pei, 1985; Yu, 1987; Bengtson *et al.*, 1990; Elicki, 1994; Esakova and Zhegallo, 1996; Gravestock *et al.*, 2001), are provided only with illustrations (Plate 2, figs. 15–18).

## SYSTEMATIC PALEONTOLOGY

Phylum Mollusca Cuvier, 1797

CLASS GASTROPODA CUVIER, 1797

SUBCLASS ARCHAEOBRANCHIA PARKHAEV, 2001

Order Helcionelliformes Golikov et Starobogatov, 1975

Superfamily Helcionelloidea Wenz, 1938

**Family Helcionellidae Wenz, 1938**

**Genus *Anuliconus* Parkhaev in Gravestock *et al.*, 2001**

*Anuliconus* Parkhaev: Gravestock *et al.*, 2001, p. 142.

*Stenotheca* Salter in Hicks, 1872: Runnegar and Jell, 1976, p. 131 (partim quoad *S. tepee*); Bengtson *et al.*, 1990, p. 243 (partim quoad *Stenotheca* sp.).

*Obtusoconus* Yu, 1979: MacKinnon, 1985, p. 68 (partim quoad *O. foliaceus*) (non Yu, 1979, p. 246).

*Isitiella* Missarzhevsky, 1983:[4] Valkov and Karlova, 1984, p. 25.

Type species. *Anuliconus magnificus* Parkhaev in Gravestock *et al.*, 2001 (by original designation), Lower Cambrian, uppermost Atdabanian and Botomian; South Australia, Yorke Peninsula (uppermost Kulpara Formation and Parara Limestone), and the Flinders Range (Mernmerna Formation).

Diagnosis and comparison. See Gravestock *et al.*, 2001, p. 142.

Species composition. In addition to the type species, six more species, i.e., *A. tepee* (Runnegar et Jell, 1976) from the lowermost Middle Cambrian of Australia (New South Wales, Coonigan Formation); *A. gonamicus* (Valkov et Karlova, 1984) from the Tommotian of the southern part of the Siberian Platform (Pestrotsvet Formation); *A. foliaceus* (MacKinnon, 1985) from the uppermost Middle Cambrian of New Zealand; *A. truncatus* Parkhaev in Gravestock *et al.*, 2001 from the Botomian of South Australia (Fleurieu Peninsula, Sellick Hill Formation); *A. campanula* Parkhaev in Gravestock *et al.*, 2001 from the uppermost Atdabanian–Botomian of South Australia (Yorke Peninsula, Kulpara Formation and Parara Limestone), and *A. tannuelliformis* sp. nov.

In addition, the forms described as *Stenotheca* sp. from the Botomian of South Australia (Oraparinna Shale, Bunyeroo Gorge) (Bengtson *et al.*, 1990, p. 244, figs. 162, B–E, H), also should be assigned to the genus *Anuliconus*.

***Anuliconus tannuelliformis* Parkhaev, sp. nov.**

Plate 1, figs. 1–3

Etymology. From the genus *Tannuella* and Latin *formis* (similar).

Holotype. PIN, specimen no. 2019/1027, internal mold of the shell; Russia, Chita Region, village of Georgievka, Uslon Section, sample no. C-84/7; Lower Cambrian, uppermost Atdabanian, Bystraya Formation.

Description. The shell is cap-shaped, evenly expanding from the apex towards the aperture, relatively low, slightly compressed laterally. The shell height is almost equal to its length. The apex is slightly shifted posteriorly and gently hooked. The anterior field is straight or slightly convex and flattens towards the aperture. Lateral and posterior fields are distinctly concave. The aperture is widely elliptical. The exterior shell ornamentation is unknown. The internal mold is ornamented by concentric, hardly prominent wide and undulating folds. The protoconch is spoon-like, slightly extended; its length is about 120 μm, width about 80 μm. A gentle constriction separates the protoconch from the teleoconch. The microornamentation of the mold surface is distinctly pitted.

Measurements, in μm:

| Specimen no. | Shell length | Shell height | Shell width |
|---|---|---|---|
| 2019/1027 (holotype) | 1170 | 930 | – |
| 2019/1026 | 1500 | 1315 | – |
| 2019/1025 | 730 | – | 400 |

Comparison. The species differs from all other members of the genus by relatively low and wide shell with concave lateral fields.

Remarks. Rather wide and relatively low shell of *A. tannuelliformis* is not typical for the genus *Anuliconus*, and brings the species together with members of the genus *Tannuella* Missarzhevsky, 1969. However, *A. tannuelliformis* is distinguished from *Tannuella* by hooked and posteriorly shifted apex.

Occurrence. Lower Cambrian, uppermost Atdabanian–Botomian of Eastern Transbaikalia.

Material. Several internal molds of shell and their fragments from the Uslon Section (sample nos. C-84/7 and C-84/8).

[3] Totally, several dozens of specimens were found in the Uslon Section (samples nos.: 7000/28, C-84/7, 7000/44, 7000/48, 7000/60, 7000/66, 7000/71, 7000/72, C-84/8, and 7000/77) and "Archaeocyathan Hill" Locality (samples nos.: 9000/2, 18/4, and C-84/4).

[4] This name does not correspond to the regulations of the ICZN and is considered a nomen nudum.

### Genus *Miroconulus* Parkhaev in Gravestock *et al.*, 2001

*Miroconulus* Parkhaev: Gravestock *et al.*, 2001, p. 145.

Type species. *Miroconulus parvulus* Parkhaev in Gravestock *et al.*, 2001 (by original designation), Lower Cambrian, uppermost Atdabanian and Botomian; South Australia, Yorke Peninsula (uppermost Kulpara Formation and Parara Limestone).

Diagnosis and comparison. See Gravestock *et al.*, 2001, p. 145.

Species composition. Type species and *M. sinitsae* sp. nov.

#### *Miroconulus sinitsae* Parkhaev, sp. nov.

Plate 1, figs. 4–6

Etymology. In honor of the geologist and paleontologist S.M. Sinitsa.

Holotype. PIN, specimen no. 2019/1090, internal mold of shell; Russia, Chita Region, village of Georgievka, Uslon Section, sample no. 7000/77; Lower Cambrian, Botomian, Bystraya Formation.

Description. The shell is cap-shaped, evenly expanding from the apex towards the aperture, high, very slightly compressed laterally. The shell height is almost equal to its length or slightly less. The apex is shifted posteriorly and gently hooked. The anterior field is convex, slightly flattens towards the aperture; the lateral fields are flattened, the posterior one is slightly concave. The aperture is widely oval, almost circular. The exterior shell ornamentation is unknown. The mold is ornamented by wide concentric, hardly prominent undulating folds. The protoconch is hemispherical, slightly extended, its diameter is about 130 μm. A slight constriction separates the protoconch from the teleoconch. The microornamentation of the mold surface is distinctly pitted.

Measurements, in μm:

| Specimen no. | Shell length | Shell height | Shell width |
|---|---|---|---|
| 2019/1090 (holotype) | 690 | 550 | 600 |
| 2019/1028 | 610 | – | 510 |
| 2019/1029 | (780) | 837 | – |

Comparison. *M. sinitsae* differs from the type species by more distinctly hooked apex, type of mold ornamentation (the mold of *M. parvulus* is ornamented by regular narrow concentric ribs), the presence of pitted microornamentation of the mold, and slightly extended protoconch.

Occurrence. Lower Cambrian, uppermost Atdabanian–Botomian of Eastern Transbaikalia.

Material. Several internal molds of shell from the Uslon Section (sample no. 7000/44, 7000/77 and C-84/7).

Superfamily Yochelcionelloidea Runnegar et Jell, 1976

### Family Yochelcionellidae Runnegar et Jell, 1976

### Genus *Yochelcionella* Runnegar et Pojeta, 1974

*Yochelcionella*: Runnegar and Pojeta, 1974, p. 31; Runnegar and Jell, 1976, p. 129; Missarzhevsky and Mambetov, 1981, p. 52; Missarzhevsky, 1989, p. 178; Bengtson *et al.*, 1990, p. 236; Esakova and Zhegallo, 1996, p. 172; Hinz-Schallreuter, 1997, p. 113; Brock, 1998, p. 577; non Wrona, 2003, p. 205 (partim quoad *?Yochelcionella* sp., fig. 13A).

*Yochelcinella*: Shabanov *et al.*, 1987, p. 122 (lapsus calami).

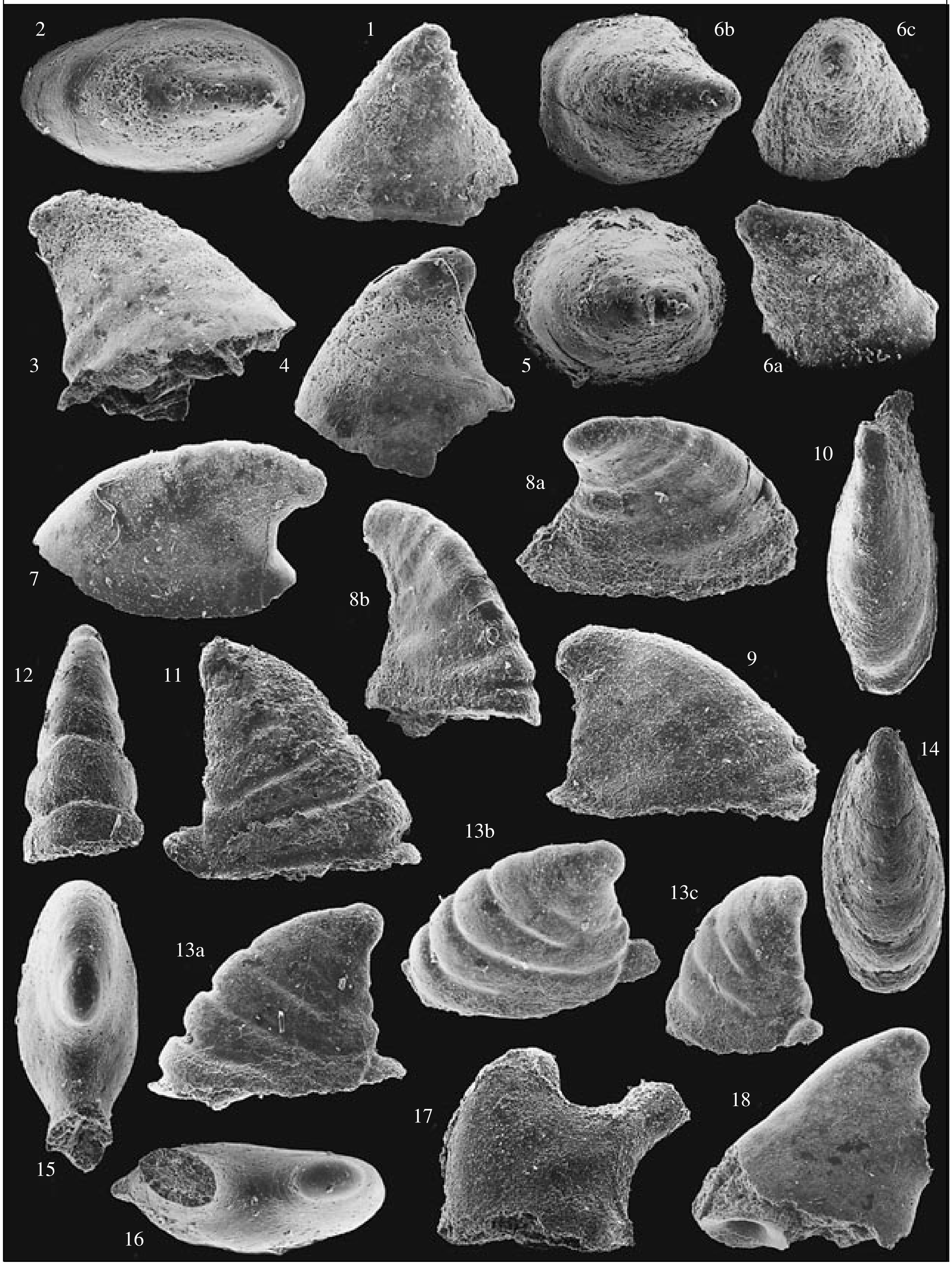
Type species. *Yochelcionella cyrano* Runnegar et Pojeta, 1974 (by original designation), basal Middle Cambrian, Coonigan Formation; New South Wales, Australia.

Diagnosis. Cap-shaped, moderately laterally compressed shell with free siphonal tube (snorkel) directed posteriorly. Apertural margin straight.

Composition. Thirteen species, in addition to the type species, i.e., *Y. erecta* (Walcott, 1891) from the uppermost Lower Cambrian (*Olenellus* Zone), Newfoundland, Canada; *Y. daleki* Runnegar et Jell, 1976 from the basal Middle Cambrian (Coonigan Formation and Murrawong Creek Formation), New South Wales, Australia; *Y. ostentata* Runnegar et Jell, 1976 from the base of the Middle Cambrian (Coonigan Formation), New South Wales, Australia; *Y. recta* Missarzhevsky in Missarzhevsky et Mambetov, 1981 from the Lower Cambrian, Atdabanian of the Malyi Karatau Range; *Y. stylifera* Missarzhevsky in Missarzhevsky et Mambetov, 1981 from the Lower Cambrian, Atdabanian of the Altai–Sayan fold belt (Isha River) and the Malyi Karatau Range; *Y. chinensis* Pei, 1985 from the Lower Cambrian, Botomian of China (Henan Province, Xinji Formation) and South Australia (Flinders Range, Oraparinna Shale); *Y. aichalica* Fedorov, 1987 from the Lower Cambrian, Atdabanian of the Anabar Region (*F. lermontovae* Zone); *Y. pelmani* Vassiljeva, 1990 from the Lower Cambrian, Tommotian of the Siberian Platform (middle reaches of the Lena River, *D. regularis* Zone); *Y. parva* Zhegallo in Esakova et Zhegallo, 1996 from the Lower Cambrian, uppermost Atdabanian–lowermost Botomian of Mongolia; *Y. crassa* Zhegallo in Esakova et Zhegallo, 1996 from the Lower Cambrian, uppermost Atdabanian–lowermost Botomian of Mongolia and Botomian of Transbaikalia; *Y. angustoplicata* Hinz-Schallreuter, 1997 from the Middle Cambrian (*Triplagnostus gibbus* Zone) of Bornholm, Denmark, *Y. fissurata* Hinz-Schallreuter, 1997 and *Y. trompetica* Hinz-Schallreuter, 1997 from the Middle Cambrian (Inka Formation), Queensland, Australia.

In addition, the specimens determined as *Yochelcionella* sp., were found in the Middle Cambrian of Spain and uppermost Lower Cambrian of Morocco (Geyer, 1986), Lower Cambrian of England (Hinz, 1987), Upper Cambrian of Bornholm, Denmark (Berg-Madsen and Peel, 1987), Lower Cambrian, Atdabanian of the Siberian Platform (middle reaches of the Lena River) (Dzik, 1994).

Plate 1



Comparison. The genus differs from the similar monotype genus *Runnegarella* Parkhaev, 2002 [type species *R. americana* (Runnegar et Pojeta, 1980)] by moderately compressed shell with straight apertural margin, from monotype genus *Enigmaconus* MacKinnon, 1985 [type species *E. parvus* MacKinnon, 1985] it is distinguished by the posteriorly directed and free siphonal tube.

#### *Yochelcionella crassa* Zhegallo in Esakova et Zhegallo, 1996

Plate 1, figs. 15–18

*Yochelcionella crassa*: Esakova and Zhegallo, 1996, p. 173, pl. 24, figs. 1–7.

Holotype. PIN, specimen no. 2019/602, internal mold of shell; Russia, Chita Region, village of Georgievka, Uslon Section, sample no. C-84/8; Lower Cambrian, Botomian, Bystraya Formation.

Description. The shell is cap-shaped, evenly expanding from the apex towards the aperture, high or moderately high, laterally compressed. The height of the shell is 1.5–2 times greater than the length of the shell. The apex is subcentral, hooked posteriorly to different extent. The anterior field is convex in the apical region, concave in the middle, with an angle approximately at the middle of the shell height, becomes straight towards the aperture. Lateral fields are flattened. The posterior field is straight or slightly concave above the snorkel, becomes concave to different extent below the snorkel. The snorkel is long, circular or widely oval in cross-section, slightly expanding distally, placed rather high (proximal end of the snorkel is placed at 1/4–1/5 of the shell height from the apex), slightly bends anteriorly and upwards. The angle between the posterior surface of the shell and the axis of snorkel in its proximal area varies from 40° to 80°. The aperture is elliptical. The exterior shell ornamentation is unknown. Internal mold is ornamented by wide concentric undulating folds, variable in prominence. The protoconch is spoon-like, its length is about 170–200 μm. A distinct constriction separates the protoconch from the teleoconch. The mold lacks any specific microornamentation.

Measurements, in μm:

| Specimen no. | Shell length | Shell height | Snorkel diameter |
|---|---|---|---|
| 2019/602 (holotype) | 1600 | 1000 | – |
| 2019/1112 | (664) | (685) | 193 |
| 2019/1181 | (797) | (816) | 200 |

Comparison. The species differs from the most similar *Y. chinensis* by higher and relatively shorter shell (shell height is 2800–3000 μm against 1600 μm in *Y. chinensis*), and with angular concave profile of the anterior field (the concavity of the anterior field in *Y. chinensis* is gentle and rounded). *Y. crassa* differs from *Y. cyrano, Y. daleki, Y. pelmani, Y. angustoplicata, Y. stylifera* and *Y. aichalica* by the strongly concave profile of the anterior field; it differs from *Y. cyrano, Y. ostentata, Y. stylifera* and *Y. aichalica* by less prominent concentric folds; it is distinguished from *Y. parva, Y. angustoplicata* and *Y. trompetica* by the absence of thin and densely placed concentric folds on the mold surface; it differs from *Y. erecta* by its hooked, rather than its straight apex, it differs from *Y. fissurata* in the absence of a septa-like fold, separating the apical part of the shell from the snorkel, from *Y. recta* it differs by the prominent apex.

Occurrence. Lower Cambrian, uppermost Atdabanian–Botomian of Eastern Transbaikalia and Mongolia.

Explanation of Plate 1

**Figs. 1–3.** *Anuliconus tannuelliformis* sp. nov.; Uslon Section, uppermost Atdabanian, sample no. C-84/7; (1) holotype no. 2019/1027, internal mold of shell, left view, ×37; (2) specimen no. 2019/1025, internal mold of shell, dorsal view, ×75; (3) specimen no. 2019/1026, internal mold of shell, right view, ×28.

**Figs. 4–6.** *Miroconulus sinitsae* sp. nov.; Uslon Section; (4) specimen no. 2019/1029, internal mold of shell, left view, ×54; uppermost Atdabanian, sample no. C-84/7; (5) specimen no. 2019/1028, internal mold of shell, dorsal view, ×68; uppermost Atdabanian, sample no. C-84/7; (6) holotype no. 2019/1090, internal mold of shell; Botomian, sample no. 7000/77: (6a) oblique right view, ×54, (6b) dorsal view, ×55, (6c) posterior view, ×55.

**Figs. 7–10.** *Parailsanella sayutinae* sp. nov.; (7) holotype no. 2019/1020, internal mold of shell, left view, ×42; Uslon Section, Botomian, sample no. C-84/8; (8) specimen no. 2019/1057, internal mold of shell; "Archaeocyathan Hill" Locality, uppermost Atdabanian, sample no. 9000/7: (8a) oblique right view, ×63, (8b) oblique anterior view, ×57; (9) specimen no. 2019/1014, internal mold of shell, right view, ×60; "Archaeocyathan Hill" Locality, uppermost Atdabanian, sample no. 18/4; (10) specimen no. 2019/1070, internal mold of shell dorsal view, ×65; "Archaeocyathan Hill" Locality, uppermost Atdabanian, sample no. 9000/7.

**Figs. 11–14.** *Parailsanella lata* Parkhaev in Gravestock *et al.*, 2001; "Archaeocyathan Hill" Locality, uppermost Atdabanian, sample no. 9000/7; (11) specimen no. 2019/1054, internal mold of shell, right view, ×49; (12) specimen no. 2019/1058, internal mold of shell, anterior view, ×52; (13) specimen no. 2019/1055, internal mold of shell: (13a) left view, ×48, (13b) oblique left view, ×49, (13c) oblique posterior view, ×42; (14) specimen no. 2019/1056, internal mold of shell, dorsal view, ×50.

**Figs. 15–18.** *Yochelcionella crassa* Zhegallo in Esakova et Zhegallo, 1996; (15) specimen no. 2019/1001, fragment of apical part of internal mold of shell, dorsal view, ×64; "Archaeocyathan Hill" Locality, uppermost Atdabanian, sample no. 18/4; (16) specimen no. 2019/1086, fragment of apical part of internal mold of shell, oblique dorsal view, ×70; Uslon Section, uppermost Atdabanian, sample no. 7000/66; (17) specimen no. 2019/1112, fragment of internal mold of shell, left view, ×53; Uslon Section, uppermost Atdabanian, sample no. 7000/66; (18) specimen no. 2019/1081, fragment of internal mold of shell, left view, ×50; Uslon Section, uppermost Atdabanian, sample no. 7000/66.

M a t e r i a l. About 20 incomplete internal molds and their fragments from the Uslon Section (sample nos. 7000/60, 7000/66, 7000/71, 7000/72, C-84/8, and 7000/77) and "Archaeocyathan Hill" Locality (sample nos. 9000/3 and 18/4).

### Family Trenellidae Parkhaev, 2001

### Genus *Parailsanella* Zhegallo in Voronova *et al.*, 1987

*Parailsanella* Zhegallo: Voronova *et al.*, 1987, p. 44; Esakova and Zhegallo, 1996, p. 158; Gravestock *et al.*, 2001, p. 172.

*Isitella* Missarzhevsky: Missarzhevsky, 1989, p. 180 (partim) (non *Isitiella* Missarzhevsky, 1983: *Stages* …, 1983, p. 98 [nomen nudum]).

*?Bemellina* Vassiljeva, 1998: Vassiljeva, 1998: p. 77.

T y p e s p e c i e s. *Parailsanella acris* Zhegallo in Voronova *et al.*, 1987 (by original designation); Atdabanian, Canada, Northwest Territories, Mackenzie Mountains (basal part of the Sekwi Formation, *"Fallotaspis"* Zone).

D i a g n o s i s a n d c o m p a r i s o n. See Gravestock *et al.*, 2001, p. 172.

S p e c i e s c o m p o s i t i o n. Six species, in addition to the type species, i.e., *P. khairkhanica* Zhegallo in Esakova et Zhegallo, 1996 from the uppermost Atdabanian–lowermost Botomian of northern Mongolia and Botomian of western Mongolia; *P. dzhargalantica* Zhegallo in Esakova et Zhegallo, 1996 from the Botomian of western Mongolia; *P. murenica* Zhegallo in Esakova et Zhegallo, 1996 from the uppermost Atdabanian–lowermost Botomian of northern Mongolia, Botomian of western Mongolia and South Australia (Parara Limestone), *P. recta* (Missarzhevsky, 1989) from the Tommotian of the Siberian Platform (middle reaches of the Lena River); *P. lata* Parkhaev in Gravestock *et al.*, 2001 from the uppermost Atdabanian–Botomian of South Australia (Kulpara Formation and Parara Limestone) and Eastern Transbaikalia (Bystraya Formation); *P. sayutinae* sp. nov. from the uppermost Atdabanian–Botomian of Eastern Transbaikalia (Bystraya Formation).

R e m a r k s. *Isitella recta* Missarzhevsky, 1989 was described by V.V. Missarzhevsky as the type species of the genus *Isitella* Missarzhevsky, 1989. The original description and illustration of this species completely agrees with the diagnosis of the genus *Parailsanella*. Because of that, I assign the species *I. recta* to *Parailsanella*, hence the genus *Isitella* should be regarded as a junior synonym of the genus *Parailsanella*. Another form, described by Hinz (1987, pl. 8, fig. 5) from the Lower Cambrian of Great Britain (Shropshire, Comley, *Strenuella* Limestone) as *Anabarella indecora* Missarzhevsky in Rozanov *et al.*, 1969 is probably also a member of the genus *Parailsanella*. The specimen described by Elicki (1994, text-figs. 4-16; 1996, p. 153, text-fig. 5, pl. 6, fig. 7) from the uppermost Atdabanian of Germany (Görlitz Syncline, upper Ludwigsdorf Member) as *Bemella* sp. probably represents the broken off apical part of *Parailsanella* sp.

#### *Parailsanella lata* Parkhaev in Gravestock *et al.*, 2001

Plate 1, figs. 11–14

*Parailsanella lata* Parkhaev: Gravestock *et al.*, 2001, p. 174, pl. 37, figs. 1–10.

H o l o t y p e. PIN, specimen no. 4664/251, internal mold of shell; South Australia, Yorke Peninsula, Horse Gully Locality; Lower Cambrian, Botomian, Parara Limestone (sample no. HG6).

D e s c r i p t i o n. The shell is cap-shaped, evenly expanding from the apex towards the aperture, slightly compressed laterally, high (the height of the shell is equal or slightly less than its length). The apex is hooked posteriorly and displaced almost to the rear aperture margin. The anterior field of the shell is evenly but strongly convex, lateral fields are hardly convex, the posterior field is concave and slightly flattened, with sharp, almost right angle transits into the parietal train. The aperture is elliptical, rather wide, narrows on the posterior part near the parietal train. The train is short but high, not narrow. The lateral margins of the aperture are evenly convex, the posterior margin intensively but gently, without angles, transits into the high train. Smooth concentric ribs ornament the exterior of the shell.

The internal mold bears sharper concentric ribs and separating grooves. The ribs are evenly prominent on the entire surface of the mold, and gradually disappear only in the apical region. The number of distinct ribs is usually three or four, rarely five. The profile of the ribs is rounded, sometimes with a slightly flattened middle part. The width of a rib increases 1.5–2 times from the posterior toward the anterior of the mold. The width of a groove is almost equal the rib width, but it is slightly narrower in the anterior part of the mold. The posterior field of the mold is separated from the train roof by a deep furrow, which is usually connected with the groove abutting the aperture. The protoconch is hemispherical, extended, separated from the teleoconch by a distinct constriction. The diameter of the protoconch is about 160–170 μm. The surface of the protoconch is smooth. Microornamentation of the internal mold is represented by irregular reticulation, which is more prominent on the ribs and usually smoothed inside the grooves. Sometimes, the ribs, and especially the surface of the train, have a pitted appearance.

M e a s u r e m e n t s, in μm:

| Specimen no. | Shell length | Shell height | Shell width |
|---|---|---|---|
| 2019/1055 | 1056 | 795 | – |
| 2019/1054 | 1017 | 915 | – |
| 2019/1056 | 980 | – | 460 |
| 2019/1058 | – | 880 | 460 |
| 2019/1074 | 800 | 600 | – |

C o m p a r i s o n. The species differs from all other members of the genus by very wide shell and less number of the concentric ribs.

Occurrence. Lower Cambrian, uppermost Atdabanian–Botomian; South Australia, Yorke Peninsula, Horse Gully Locality (Kulpara Formation and Parara Limestone), Borehole Minlaton-1 (Parara Limestone); Flinders Range, Borehole Yalkalpo-2 (Mernmerna Formation); Eastern Transbaikalia, village of Georgievka (Bystraya Formation).

Material. Several dozens of internal molds of shell from the Uslon Section (sample nos. 7000/60, 7000/66, 7000/71, and 7000/72) and "Archaeocyathan Hill" Locality (sample nos. 18/4, 9000/3, and 9000/7).

***Parailsanella sayutinae*** **Parkhaev, sp. nov.**

Plate 1, figs. 7–10

Etymology. In honor of paleontologist T.A. Sayutina.

Holotype. PIN, specimen no. 2019/1020, internal mold of shell; Russia, Chita Region, village of Georgievka, Uslon Section, sample no. C-84/8; Lower Cambrian, Botomian, Bystraya Formation.

Description. The shell is cap-shaped, evenly expanding from the apex towards the aperture, strongly compressed laterally, rather low (the shell is 0.67 times as high as its length). The apex is hooked posteriorly and displaced almost to the rear aperture margin. The anterior field is evenly and strongly convex, the lateral fields are flattened, the posterior one is concave and flattened in the middle, with sharp but blunt angle transits into the parietal train. The aperture is elliptical, not wide, narrowing slightly in the parietal train area. The train is short, low and moderately narrow. The lateral margins of the aperture are slightly convex, the posterior margin gently transits in to the train, without angles. The exterior shell ornamentation is unknown.

The internal mold bears smooth concentric ribs and separating grooves. The ribs are evenly prominent on the entire surface of the mold, and gradually disappear only in the apical region. The number of distinct ribs is four to six. The profile of the ribs is rounded, with slightly flattened middle part. The ribs increase in width approximately 1.5 times from the posterior to the anterior of the mold. The grooves are slightly narrower than the ribs. The posterior field of the mold is separated from the train roof by a shallow furrow (indistinct on some specimens), which is usually connected with the groove abutting the aperture. The protoconch is hemispherical, extended, separated from the teleoconch by a distinct constriction. The diameter of the protoconch is about 170–190 μm. The surface of the protoconch is smooth. Microornamentation of the internal mold is represented by irregular reticulation, which is more prominent on the ribs. A single specimen (Plate 1, fig. 9) displays five faint and distant radial threads on the mold surface.

Measurements, in μm:

| Specimen no. | Shell length | Shell height | Shell width |
|---|---|---|---|
| 2019/1020 (holotype) | 1345 | 840 | – |
| 2019/1014 | 872 | 618 | – |
| 2019/1024 | 873 | 600 | – |
| 2019/1067 | 972 | 682 | – |
| 2019/1059 | 1000 | 690 | – |
| 2019/1010 | 785 | – | 300 |
| 2019/1070 | 750 | – | 250 |

Comparison. The species differs from *P. acris* by smaller shell with stronger hooked apex. It is distinguished from *P. khairkhanica* and *P. dzhargalantica* by a lower shell with stronger hooked apex, from *P. lata* by narrower shell, and by narrower and less sharp concentric folds, from *P. murenica* by wider shell with smoothed, not sharp folds, from *P. recta* by a lower shell with stronger hooked apex, and narrower and more densely placed concentric folds.

Occurrence. Lower Cambrian, uppermost Atdabanian–Botomian of Eastern Transbaikalia.

Material. Over twenty internal molds of shells and their fragments from the Uslon Section (sample nos. 7000/44, 7000/60, 7000/66, 7000/71, 7000/72, and 7000/77), and "Archaeocyathan Hill" Locality (sample nos. C-84/4, 18/4, 9000/2, 9000/7, and 9000/9).

**Family Stenothecidae Runnegar et Jell, 1980**

**Subfamily Stenothecinae Runnegar et Jell, 1980**

**Genus *Stenotheca* Salter in Hicks, 1872**

*Stenotheca* Salter in Hicks, 1872: Runnegar and Jell, 1976, p. 131 (partim); Yu, 1987, p. 191; Bengtson *et al.*, 1990, p. 243 (partim); Feng *et al.*, 1994, p. 8 (partim); Landing and Bartowski, 1996, p. 753 (partim); Gravestock *et al.*, 2001, p. 182.

*Anabarella* Vostokova, 1962: He *et al.*, 1984, p. 351 (non Vostokova, 1962, p. 56).

Type species. *Stenotheca cornucopia* Salter in Hicks, 1872 (by original designation); Middle Cambrian, Great Britain, Wales.

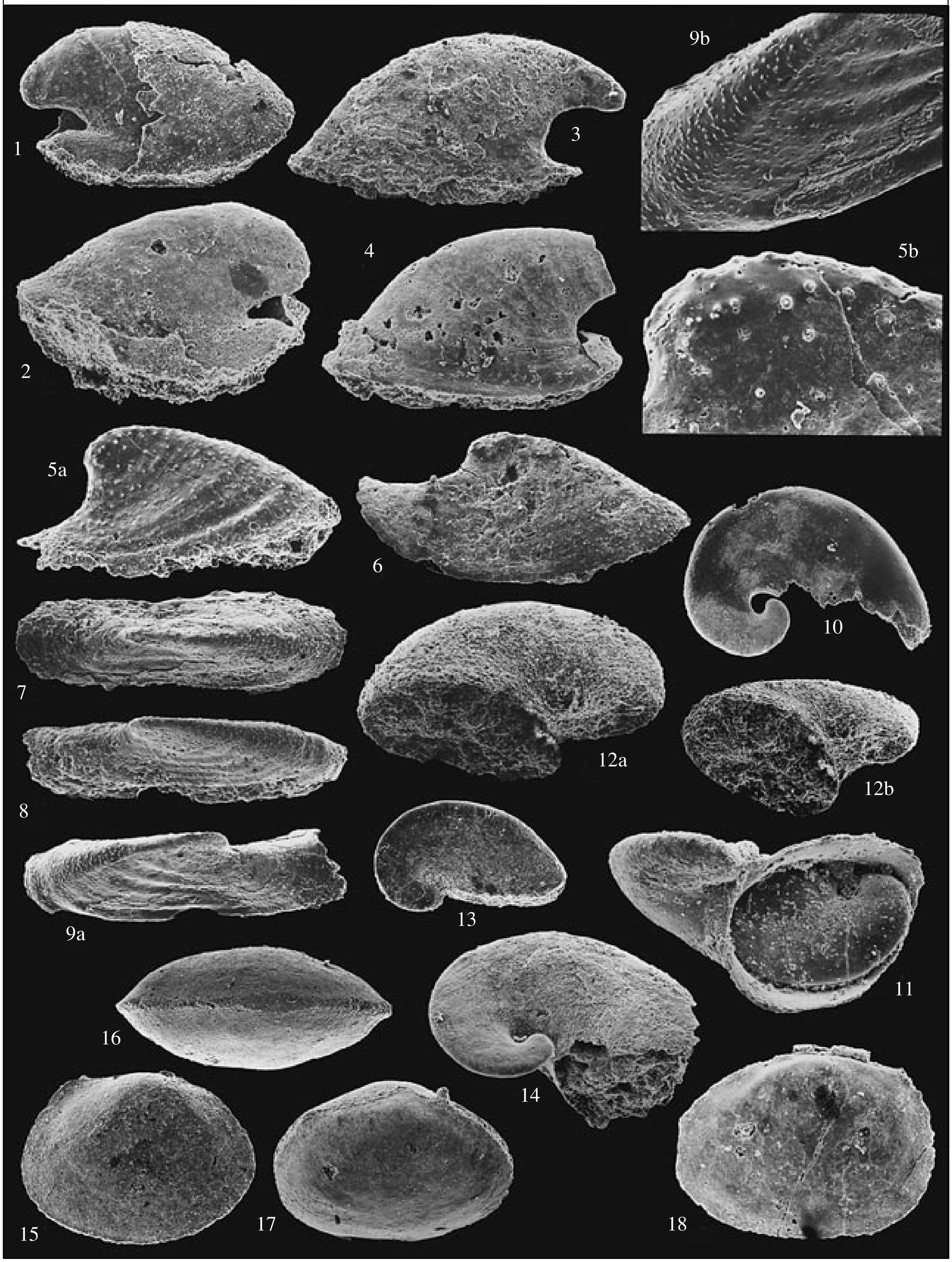
Diagnosis and comparison. See Gravestock *et al.*, 2001, p. 182.

Species composition. In addition to the type species, three more species, i.e., *S. drepanoida* (He et Pei in He *et al.*, 1984) from the Lower Cambrian, Botomian of China (Xinji Formation, Shuijintuo Formation, and Yutaishan Formation) and South Australia (Parara Limestone and Ajax Limestone), *S. acutacosta* Walcott, 1890 from the Lower Cambrian of Newfoundland (Brigus Formation) and *S. transbaikalica* sp. nov.

In addition, the mollusks described by Geyer (1986, pl. 3, figs. 43–47) as "Genus incertum et species incerta B" and "Genus incertum et species incerta C" from the uppermost Lower–lowermost Middle Cambrian of Morocco, probably also belong to *Stenotheca*.

Remarks. The following species previously referred to *Stenotheca* do not correspond to the diagno-

Plate 2



sis of the genus and should be excluded from it: *S. pauper* Billings, 1872 (Brasier, 1984, p. 243, figs. 3e–3g) and *S. lata* Cobbold, 1935 (Cobbold, 1935, p. 42, pl. 2, figs. 14, 15) have wide and low shell (the first species is closer to the genus *Ilsanella* Missarzhevsky, 1981, the second one can be assigned to *Bemella* Missarzhevsky in Rozanov et al., 1969); *S. angusta* Cobbold, 1935 (Cobbold, 1935, p. 41, pl. 2, figs. 11–13) has rather wide shell with very strongly hooked apex, so that the shell is planispiral (the species should be assigned to the family Coreospiridae); *S. rugosa* var. *acutacosta* Walcott, 1891 (see Kerber, 1988, described as *Ginella acuticosta* (Walcott, 1891), p. 167, pl. 3, figs. 17, 18) and *S. rugosa abrupta* Shaler et Foerste, 1888 (see Hinz, 1987, p. 55, pl. 8, figs. 1, 2, 9 and text-fig. 1B) have rather wide and high shells with slightly posteriorly hooked apex, and with no train (both species are similar to *Obtusoconus* Yu, 1979 or *Anuliconus* Parkhaev in Gravestock *et al.*, 2001); *S. pojetai* Runnegar et Jell, 1976 (Runnegar and Jell, 1976, p. 131, pl. 8A, figs. 7–10) has rather wide shell, the apex is massive, not pointed (probably it represents a new genus of the family Trenellidae); *S. tepee* Runnegar et Jell, 1976 (Runnegar and Jell, 1976, p. 131, pl. 8A, figs. 5, 6, 11, 12) and the specimens described by B. Runnegar (Bengtson *et al.*, 1990, p. 244, fig. 162, B–E, H) as *Stenotheca* sp. display relatively wide shells with almost straight, slightly posteriorly hooked apex, the train is absent (both forms are assigned to *Anuliconus*); *S. taconica* Landing et Bartowski, 1996 (Landing and Bartowski, 1996, p. 753, figs. 5.5, 5.7–5.9, 10.2, 10.3) has a relatively wide shell without a train, the apex is almost central (the species should be referred to a new genus of the family Helcionellidae); *S. cornu* Wiman, 1903 has no affinities to mollusks at all, but represents a tommotiid sclerite of the genus *Lapwortella*. In addition to the species mentioned above, *S. curvirostra* Shaler et Foerste, 1888 is sometimes cited in literature, but its actual generic position remained uncertain.

#### ***Stenotheca transbaikalica*** **Parkhaev, sp. nov.**

Plate 2, figs. 3 and 4

E t y m o l o g y. From Transbaikalia.

H o l o t y p e. PIN, specimen no. 2019/1045, internal mold of shell; Russia, Chita Region, village of Georgievka, Uslon Section, sample no. 7000/71; Lower Cambrian, Botomian, Bystraya Formation.

D e s c r i p t i o n. The shell is cap-shaped, evenly expanding from the apex towards the aperture, strongly compressed laterally, low (the shell is approximately twice as high as long). The apex is pointed, hooked and strongly displaced posteriorly, projecting over the rear apertural margin. The anterior field of the shell is evenly convex, becomes straighter towards the aperture. Lateral fields are flat, almost vertical. The posterior field is strongly concave, with almost right but rounded angle transits into the parietal train. The aperture is very narrow and oval. The lateral margins of the aperture are slightly convex, the posterior margin at the transition to the train is gently arched and forms a low sinus. The external shell ornamentation is unknown. The internal mold bears faint irregular concentric folds. The protoconch is small (its diameter is about 80 μm), separated from the teleoconch by a gentle constriction.

M e a s u r e m e n t s, in μm:

| Specimen no. | Shell length | Shell height |
|---|---|---|
| 2019/1045 (holotype) | 755 | 390 |
| 2019/1044 | (600) | 345 |

E x p l a n a t i o n o f P l a t e 2

**Figs. 1 and 2.** *Anabarella tshitaensis* sp. nov.; Uslon Section, Botomian, sample no. C-84/8; (1) holotype no. 2019/1036, internal mold with fragment of shell, right view, ×73; (2) specimen no. 2019/1037, internal mold of shell, left view, ×120.

**Figs. 3 and 4.** *Stenotheca transbaikalica* sp. nov.; Uslon Section, Botomian, sample no. 7000/71; (3) holotype no. 2019/1045, internal mold of shell, left view, ×84; (4) specimen no. 2019/1044, internal mold of shell, left view, ×87.

**Figs. 5–9.** *Mellopegma uslonica* sp. nov.; Uslon Section, Botomian; (5) specimen no. 2019/1125, internal mold of shell; sample no. 7000/81: (5a) right view, ×70; (5b) fragment of ornamentation of the apical part of the internal mold of shell, ×286; (6) specimen no. 2019/1047, internal mold of shell, right view, ×63, sample no. 7000/71; (7) specimen no. 2019/1049, internal mold of shell dorsal view, ×55, sample no. 7000/71; (8) specimen no. 2019/1052, internal mold of shell, right view, ×50, sample no. 7000/71; (9) holotype no. 2019/1051, internal mold of shell, sample no. 7000/71: (9a) oblique dorsal view, ×52, (9b) fragment of ornamentation of the anterolateral surface of the internal mold of shell, ×120.

**Figs. 10–14.** *Pelagiella adunca* Missarzhevsky in Rozanov et Missarzhevsky, 1966; (10) specimen no. 2019/1008, internal mold of shell, apical view, ×44; "Archaeocyathan Hill" Locality, uppermost Atdabanian, sample no. 18/4; (11) specimen no. 2019/1018, shell, apertural view, ×80; "Archaeocyathan Hill" Locality, uppermost Atdabanian, sample no. 18/4; (12) specimen no. 2019/1116, internal mold of sinistral shell; "Archaeocyathan Hill" Locality, uppermost Atdabanian, sample no. 9000/2: (12a) oblique apical view, ×61, (12b) same view, ×42; (13) specimen no. 2019/1099, internal mold of juvenile shell, apical view, ×43; Uslon Section, uppermost Atdabanian, sample no. 7000/66; (14) specimen no. 2019/1013, internal mold of shell, oblique apical view, ×52; "Archaeocyathan Hill" Locality, uppermost Atdabanian, sample no. 18/4.

**Figs. 15–18.** *Pojetaia runnegari* Jell, 1980; (15) specimen no. 2019/1096, internal mold of the shell, view on the right valve, ×42; Uslon Section, uppermost Atdabanian, sample no. 7000/66; (16) specimen no. 2019/1076, internal mold of shell, ventral view, ×43; Uslon Section, uppermost Atdabanian, sample no. 7000/60; (17) specimen no. 2019/1039, internal mold of shell, view on the right valve, ×52; Uslon Section, Botomian, sample no. C-84/8; (18) specimen no. 2019/1006, internal mold of shell, view on the left valve, ×52; "Archaeocyathan Hill" Locality, uppermost Atdabanian, sample no. 18/4.

Comparison. The species differs from all other members of the genus in the low and relatively long shell.

Material. Two internal molds from the Uslon Section (sample no. 7000/71).

## Genus *Anabarella* Vostokova, 1962

*Anabarella*: Vostokova, 1962, p. 56; Rozanov *et al.*, 1969, p. 144; Runnegar and Jell, 1976, p. 130; MacKinnon, 1985, p. 69; Yu, 1987, p. 191; Valkov, 1987, p. 121; Missarzhevsky, 1989, p. 177; Bengtson *et al.*, 1990, p. 244; Esakova and Zhegallo, 1996, p. 169; (non He *et al.*, 1984, p. 351); Gravestock *et al.*, 2001, p. 184; Gubanov and Peel, 2003, p. 1077; non Wrona, 2003, p. 205 (partim quoad *A.* cf. *argus*, fig. 13B).

*Planutenia*: Elicki, 1994, p. 81.

Type species. *Anabarella plana* Vostokova, 1962 (by original designation); uppermost Precambrian, Nemakit-Daldynian–Lower Cambrian, Tommotian; Siberian Platform, western Mongolia, Poland, Canada, and China [=*A. exigua* Zhegallo in Voronin *et al.*, 1982; =*A. gypirhynchosa* He in Xing *et al.*, 1984].

Diagnosis and comparison. See Gravestock *et al.*, 2001, p. 184.

Species composition. The following seven species in addition to the type species: *A. lentiformis* Yue in Xing *et al.*, 1984 from the Tommotian of China, Shanxi Province (uppermost Dengying Formation), *A. simesi* MacKinnon, 1985 from the uppermost Middle Cambrian of New Zealand and from the Middle Cambrian of Australia (New South Wales, Murrawong Creek Formation); *A. applanta* Jermak in Jermak et Pelman, 1986 from the uppermost Atdabanian of Siberia (Kharaulakh Range); *A. emeiensis* Yu, 1987 [=*A. emeiensis* Yu in Lu, 1979 (nomen nudum)] from China, Tommotian, Sichuan Province (Hongchunping Formation, Maidiping Member) and the Botomian, Henan Province, Fangcheng (Xinji Formation); *A. australis* Runnegar in Bengtson *et al.*, 1990 [=*A. argus* Runnegar in Bengtson *et al.*, 1990] from the uppermost Atdabanian–lowermost Botomian of South Australia (Kulpara Formation, Parara Limestone and Ajax Limestone); *A. flectata* (Elicki, 1994) [=*A. inclinata* (Elicki, 1994)] from the Atdabanian of Germany (Görlitz Syncline, upper Ludwigsdorf Member); *A. tshitaensis* sp. nov.

Remarks. The placement of the species from the Atdabanian of Germany in a separate genus *Planutenia* Elicki, 1994 is dubious. The strongly hooked apex and hence involute shell of *Planutenia*, distinguishing it from *Anabarella*, is a character that can vary considerably between different species of *Anabarella* or even within a single species.

Probably, the forms described by Gubanov and Peel (2003, pl. 3, figs. 1–15) from the Lower Cambrian of Spain (Sierra Morena) as *A. plana* should be excluded from the type species of the genus and referred to a new species, due to coarse and regularly placed concentric ribs of the Spanish specimens.

### *Anabarella tshitaensis* Parkhaev, sp. nov.

Plate 2, figs. 1 and 2

*Anabarella* sp.: Parkhaev, 2004, pl. 2, fig. 2.

Etymology. After the Chita Region, where the type locality is situated.

Holotype. PIN, specimen no. 2019/1036, internal mold with fragments of the shell; Russia, Chita Region, village of Georgievka, Uslon Section, sample no. C-84/8; Lower Cambrian, Botomian, Bystraya Formation.

Description. The shell is cap-shaped, evenly expanding from the apex towards the aperture, strongly compressed laterally, low (the shell length is approximately 1.7 times greater than its height). The apex is displaced up to the level of rear aperture margin or even projected over it, slightly hooked downwards, but not adjoining the roof of the parietal train. The anterior field of the shell is evenly convex, flattens insignificantly towards the aperture, and is sometimes slightly explanate. The lateral fields are flat, almost vertical. The posterior field is concave and transits with a sharp angle into the roof of the parietal train. The aperture is narrow, elongated oval, slightly wider anteriorly and narrows towards the posterior end. The lateral margins of the aperture are gently convex. The posterior margin of the aperture is gently bent upwards and forms a sinus of the parietal train just below the apex. The train is rather high and of moderate length. Externally, the shell surface is smooth. The mold also lacks the ornamentation; only at the transition of the posterior field to the train the cellular microornament takes place. This has been interpreted as an imprint of shell muscle (Parkhaev, 2004). The protoconch is rounded, compressed laterally, very indistinctly separated from the teleoconch. The protoconch diameter is about 110–120 μm.

Measurements, in μm:

| Specimen no. | Shell length | Shell height |
|---|---|---|
| 2019/1036 (holotype) | 695 | 415 |
| 2019/1038 | 719 | (375) |
| 2019/1037 | 495 | 352 |

Comparison. The new species differs from *A. applanta*, which is very similar in shell shape, in the smaller protoconch (it is 170–180 μm in *A. applanta*). From *A. plana* it is distinguished by smaller size of lower and more elongated shell, from *A. lentiformis* it differs in the absence of regular concentric ornamentation; from *A. simesi* and *A. australis* is differs in the more massive apex; from *A. emeiensis* it differs in the lower shell without concentric ornamentation. The new species differs from *A. flectata* in the absence of concentric folds and in the smaller diameter of the protoconch, which is half that of *A. flectata*.

Material. Three internal molds of shell from the Uslon Section (sample nos. C-84/8 and 7000/81).

### Genus *Mellopegma* Runnegar et Jell, 1976

*Mellopegma*: Runnegar and Jell, 1976, p. 130; Missarzhevsky, 1989, p. 179, pl. 6, figs. 10, 11; Landing *et al.*, 2002, p. 298 (non Zhou and Xiao, 1984, pl. 3, fig. 11).

*Anabarella* Vostokova, 1962: Rozanov *et al.*, 1969 (partim quoad *A. indecora*), p. 144, pl. 4, figs. 7, 8; *Stages…*, 1983 (partim quoad *A. indecora*), p. 99, pl. 34, fig. 1; Khomentovsky and Karlova, 1989 (partim quoad *A. indecora*), p. 52, pl. 4, fig. 9 (non Vostokova, 1962, p. 56).

T y p e s p e c i e s. *Mellopegma georginensis* Runnegar et Jell, 1976 (by original designation); Middle Cambrian of Australia, Queensland (Georgina Basin, Currant Bush Limestone) and uppermost Lower Cambrian of Canada, Quebec (“Anse Maranda” Formation).

D i a g n o s i s. Shell cap-shaped, evenly and very rapidly expanding from apex towards aperture, low, strongly compressed laterally. Apex blunt, hooked and slightly displaced posteriorly. Aperture narrow, irregularly oval, lateral margins strongly convex, posterior apertural margin arched under train forming high sinus. Ornamentation represented by combination of concentric folds and growth lines, rarely only growth lines present.

S p e c i e s c o m p o s i t i o n. Two species, besides the type species, i.e., *M. indecora* (Missarzhevsky in Rozanov *et al.*, 1969) from the Tommotian (*A. sunnaginicus–D. regularis* zones) of the Siberian Platform (Anabar Region, Aldan River; Uchur–Maya Region and middle reaches of the Lena River) and the Tommotian of the Kuznetsky Alatau; *M. uslonica* sp. nov. In addition, *Mellopegma* sp. was listed for the Botomian of Mongolia (Esakova and Zhegallo, 1996, p. 51).

C o m p a r i s o n. The genus differs from *Stenotheca* Salter in Hicks, 1872 and *Anabarella* Vostokova, 1962 in the low, depressed shell with less hooked and less posteriorly displaced apex, and strongly convex apertural margin.

R e m a r k s. *Mellopegma nana* Zhou et Xiao, 1984 from the Lower Cambrian, Botomian? of northern China (Anhui Province, Yutaishan Formation) and the Botomian of South Australia (Parara Limestone and Sellick Hill Formation) was re-assigned to the genus *Figurina* Parkhaev in Gravestock *et al.*, 2001 of the family Trenellidae.

#### *Mellopegma uslonica* Parkhaev, sp. nov.

Plate 2, figs. 5–9

E t y m o l o g y. After the type locality.

H o l o t y p e. PIN, specimen no. 2019/1051, internal mold; Russia, Chita Region, village of Georgievka, Uslon Section, sample no. 7000/71a; Lower Cambrian, Botomian, Bystraya Formation.

D e s c r i p t i o n. The shell is cap-shaped, evenly and very rapidly expanding from the apex towards the aperture, strongly compressed laterally, low (the shell length is approximately two times greater than its height). The apex is blunt, hooked and displaced up to the posterior 1/3 or 1/4 of the shell. The anterior field is evenly convex. The lateral fields are flat, almost vertical; the posterior field is concave, with a rounded angle transiting into the almost horizontal roof of the parietal train. The aperture is very narrow, irregularly oval in outlines, i.e., slightly expanding in the anterior and posterior parts, but narrowing in the middle. The lateral margins of the aperture are strongly convex, the posterior apertural margin bends at the transition to the train, forming a high sinus. The exterior shell ornamentation is unknown. The internal mold is smooth or may have irregular concentric folds, more prominent on the lateral fields and smoothed out from the anterior field. The microornamentation is represented by spherical granules (10 μm in diameter), which are aligned in rows parallel to the concentric folds. The protoconch is not prominent; diameter of the apex is about 100 μm.

M e a s u r e m e n t s, in μm:

| Specimen no. | Shell length | Shell height | Shell width |
|---|---|---|---|
| 2019/1051 (holotype) | 1200 | – | 270 |
| 2019/1119 | 1040 | 420 | – |
| 2019/1101 | 1115 | 500 | – |
| 2019/1100 | 980 | – | 245 |
| 2019/1046 | 1095 | 600 | – |
| 2019/1047 | 960 | 450 | – |
| 2019/1049 | 1152 | – | 304 |
| 2019/1120 | 1155 | – | 267 |
| 2019/1115 | 1540 | – | 330 |
| 2019/1116 | 1035 | 505 | – |
| 2019/1124 | 1155 | 670 | – |
| 2019/1125 | 900 | 440 | – |

C o m p a r i s o n. *M. uslonica* differs from the type species, which is very similar in the shell shape, by its more compressed shell. This is especially noticeable on the anterior field, which is slightly expanded in respect to the entire shell of *M. georginensis*. In addition, the ribs of ornamented specimens of *M. uslonica* are not so regular as in *M. georginensis*, and do not reach the anterior field. The new species differs from *M. indecora* in its lower shell and in the absence of the ribs on the anterior field of the mold.

O c c u r r e n c e. Lower Cambrian, Botomian of Eastern Transbaikalia.

M a t e r i a l. Several dozen internal molds and their fragments from the Uslon Section (sample nos. 7000/71 and 7000/81).

Order Pelagielliformes Mackinnon, 1985

### Family Pelagiellidae Knight, 1952

### Genus *Pelagiella* Matthew, 1895

*Pelagiella*: Matthew, 1895, p. 131; Wenz, 1938, p. 95; Kobayashi, 1939, p. 287; Lochman, 1956, p. 1370; ?Lochman and Hu, 1959, p. 425, pl. 60, figs. 19–21; Knight *et al.*, 1960, p. I323; Rozanov and Missarzhevsky, 1966, p. 101; Matthews and Missarzhevsky, 1975, p. 295; Runnegar and Jell, 1976, p. 134; Landing *et al.*, 1980, p. 407; Ermak and Pel’man, 1986, p. 188; Geyer, 1986,

p. 93; Bengtson *et al.*, 1990, p. 252; Elicki, 1996, p. 154; Brock, 1998, p. 583; Gravestock *et al.*, 2001, p. 191; Landing *et al.*, 2002, p. 299; Wrona, 2003, p. 205 (non Palmer, 1982, p. 10, pl. 2, figs. 11, 12).

*Parapelagiella*: Kobayashi, 1939, p. 287.

*Auriculaspira*: Zhou and Xiao, 1984, p. 134, 138; Yu and Rong, 1991, p. 339, 343; Feng *et al.*, 1994, p. 10.

*Auriculatespira*: He *et al.*, 1984, p. 352 (lapsus calami).

Type species. *Cyrtolithes atlantoides* Matthew, 1895 (by original designation); Lower Cambrian, ?Atdabanian; Canada, New Brunswick.

Diagnosis and comparison. See Gravestock *et al.*, 2001, p. 191.

Species composition. At present, the genus *Pelagiella* includes over twenty nominate species, the differences between which are sometimes very uncertain. Thus, the great necessity of a thorough systematic revision of the species based on the study of the type material is obvious. All nominate species of *Pelagiella*, which I managed to find in the literature, are listed below.

In addition to the type species, the genus includes the following taxa: *P. primaeva* (Billings, 1872) from the Lower Cambrian, Botomian of New York, United States (uppermost Browns Pond Formation) and uppermost Lower Cambrian of Canada, Quebec ("Anse Maranda" Formation); *P. subangulata* (Tate, 1892) [=*Pelagiella emeishanensis* He in Xing *et al.*, 1984] from the Lower Cambrian, uppermost Atdabanian–lowermost Toyonian of South Australia, lowermost Botomian of China (Sichuan Province) and uppermost Atdabanian of Germany (uppermost Ludwigsdorf Member); *P. minutissima* (Walcott, 1912) and *P. hoyti* (Walcott, 1912) from Hoyt Limestone, New York, United States; *P. willsi* (Walcott, 1913) from the Middle Cambrian of China (Shanxi Province); *P. cyltia* (Walcott, 1913) and *P. pagoda* (Walcott, 1913) from the Upper Cambrian of China (Shandong Province, Chaumitien Limestone); *P. hinomotoensis* Kobayashi, 1933 from the Upper Cambrian of Eastern Asia (China, Wuhutsui Basin, Liaodong); *P. hana* Kobayashi, 1935 from the Upper Cambrian of South Korea; *P. escayachensis* Kobayashi, 1937 from the Upper Cambrian of Argentina (Catamarca Province); *P. kreklingensis* Kobayashi, 1939 from the Middle? Cambrian of Denmark (Bornholm); *P. lorenzi* Kobayashi, 1939 [=*Raphistoma broeggeri* Gronwall, 1902 sensu Lorenz, 1906, non Gronwall, 1902; non *P. lorenzi* Kobayashi sensu Missarzhevsky in Rozanov et Missarzhevsky, 1966] from the Lower Cambrian of China and lowermost Atdabanian of Iran (Upper Dolomite Member, Soltaniyeh Formation, Vali Abad Section); *P. adunca* Missarzhevsky, 1966 [=*P. lorenzi* Kobayashi sensu Missarzhevsky in Rozanov et Missarzhevsky, 1966, syn. nov., =*P. bentica* Jermak in Jermak et Pelman, 1986, syn. nov., =*P. serpentis* Jermak in Jermak et Pelman, 1986, syn. nov.; =*P. asymmetrica* Jermak in Jermak et Pelman, 1986, syn. nov., ?=*P. repinae* Vassiljeva, 1998, syn. nov.][5] from the Lower Cambrian, Atdabanian and Botomian of the Siberian Platform, Malyi Karatau Range, Altai-Sayan fold belt and Transbaikalia; *P. corinthiana* Runnegar et Jell, 1976 [=*P. deltoids* Runnegar et Jell, 1976, syn. nov.] from the Middle Cambrian of Australia, Queensland, Currant Bush Limestone (I consider both these forms, coming from the same locality, as conspecific, since their differences correspond to the general type of ontogenetic variability of pellagiellas); *P.* cf. *P. deltoids* Runnegar et Jell, 1976 from the Middle Cambrian of Australia (New South Wales, Murrawong Creek Formation); *P. madianensis* (Zhou et Xiao, 1984) [=*P. adunca* (He et Pei in He *et al.*, 1984)] from the Lower Cambrian, uppermost Atdabanian–lowermost Toyonian of China, South Australia, and the Antarctic; *P. crassa* Geyer, 1986 from the base of the Middle Cambrian of Spain; *P. atlasensis* Geyer, 1986 and *P.* aff. *P. lorenzi* Kobayashi, 1939 from the uppermost Lower Cambrian and lowermost Middle Cambrian of Morocco. In addition, *Pelagiella* sp. was listed for the Lower Cambrian, Atdabanian (*Callavia* Zone) of Canada, Nova Scotia (Landing *et al.*, 1980), uppermost Atdabanian (uppermost Ludwigsdorf Member) of Germany (Elicki, 1996), lowermost Middle Cambrian (*Cephalopyge* Zone, lowermost Djebel Vavrmast Formation) of Morocco (Geyer, 1986), Middle Cambrian (Marjum Formation) of Utah, United States (Robison, 1964), Lower Cambrian (Buelna Formation) of Mexico, Sonora (McMenamin and McMenamin, 1990), whereas *"Pelagiella"* sp. indet. was found in the Middle Cambrian of Antarctic (Wolfart, 1994).

[5] See Remarks in the description of the species *Pelagiella adunca* Miss.

***Pelagiella adunca*** **Missarzhevsky in Rozanov et Missarzhevsky, 1966**

Plate 2, figs. 10–14

*Pelagiella lorenzi* Kobayashi, 1939: Rozanov and Missarzhevsky, 1966, p. 102, pl. 11, fig. 3; Matthews and Missarzhevsky, 1975, p. 295, pl. 1, figs. 1, 4; *Stages…*, 1983, p. 100, pl. 34, fig. 4; Ermak and Pel'man, 1986, p. 190, pl. 26, figs. 3–6; Missarzhevsky, 1989, p. 182, pl. 8, figs. 6, 10 (non Kobayashi, 1939, p. 284, text-fig. on p. 284; non Zhong, 1977, pl. 2, figs. 12, 13 [?=*P. madianensis* (Zhou et Xiao, 1984)]; non Elicki, 1994, figs. 6, 7 [=*P. subangulata* (Tate, 1892)]; non Elicki, 1996, p. 154, pl. 7, figs. 1–5 [=*P. subangulata* (Tate, 1892)]; non Hamdi, 1995, pl. 16, figs. 1–6 [?=*P. lorenzi* Kobayashi, 1939]).

*Pelagiella adunca* Missarzhevsky: Rozanov and Missarzhevsky, 1966, p. 103, pl. 11, figs. 1, 2; Ermak and Pel'man, 1986, p. 190, pl. 26, figs. 7, 8; non *P. adunca* (He et Pei in He *et al.*, 1984) [=*P. madianensis* (Zhou et Xiao, 1984)].

*Pelagiella serpentis* Ermak: Ermak and Pel'man, 1986, p. 191, pl. 26, figs. 9, 10 (syn. nov.).

*Pelagiella bentica* Ermak: Ermak and Pel'man, 1986, p. 192, pl. 26, figs. 11, 12 (syn. nov.).

*Pelagiella asymmetrica* Ermak: Ermak and Pel'man, 1986, p. 193, pl. 27, figs. 1–3 (syn. nov.).

*?Pelagiella repinae* Vassiljeva: Vassiljeva, 1998, p. 83, pl. 5, figs. 1, 2, 5 (syn. nov.).

Holotype. Geological Institute of the Russian Academy of Sciences, no. 3470/72, Altai, Isha River; Lower Cambrian, Atdabanian, Kameshki Horizon.

Description. The shell is composed of one and a half of rapidly expanding whorls. The spire of adult shell is located at the level of the upper aperture margin. The last whorl is wide, becomes irregular oval near the aperture, with slightly extended basal wall and moderately extended parietal wall. The superperipheral surface of the last whorl is flattened or slightly concave to the apex. The umbilicus is narrow and shallow. The shell exterior bears fine growth lines, the mold surface lacks any specific microornamentation.

Measurements, in μm:

| Specimen no. | Larger shell diameter | Shell height | Aperture width |
|---|---|---|---|
| 2019/1018 | 743 | 430 | 500 |
| 2019/1013 | 1380 | – | 970 |
| 2019/1013 | 1100 | – | – |
| 2019/1011 | 1190 | – | – |
| 2019/1011 | 1050 | – | 685 |
| 2019/1008 | 1122 | – | 635 |
| 2019/1007 | 1770 | – | 1110 |
| 2019/1006 | 945 | – | 585 |
| 2019/1005 | 870 | – | 510 |
| 2019/1116 | 980 | 460 | 680 |

Comparison. *P. adunca* differs from the type species in the smaller shell (shell diameter of *P. atlantoides* is up to 9 mm), lower rate of whorls coiling, and consequently, less ratio of aperture width to shell diameter. The species differs from very similar *P. subangulata* (Tate, 1892) by the absence of carina on the shell base (however, it is not always present in *P. subangulata*) and more flattened superperipheral part of the shell. Since the shells of *P. subangulata* are extremely variable (Gravestock *et al.*, 2001, p. 194), further detailed studies may reveal the conspecifity of *P. adunca* and *P. subangulata*.

Remarks. As it was already noted (Gravestock *et al.*, 2001, p. 193), the pelagiellas described by Missarzhevsky (Rozanov and Missarzhevsky, 1966) from the Atdabanian of the Siberian Platform as *P. lorenzi* Kobayashi, 1939, and later repeatedly reported from numerous localities of the Lower Cambrian of North Asia (Matthews and Missarzhevsky, 1975; *Stages*…, 1983; Ermak and Pel'man, 1986; Missarzhevsky, 1989), do not in fact represent true *P. lorenzi* Kobayashi, 1939. Judging from the illustration in the original description of the species by T. Kobayashi (1939, text-fig. on p. 284), true *P. lorenzi* from the Middle Cambrian of China [=*Raphistoma broeggeri* Gronwall, 1902 sensu Lorenz, 1906, non Gronwall, 1902] has a gently convex superperipheral part of the shell with a projecting spire, and fine, dense axial ribs on the basal part of the shell. At the same time, *P. lorenzi* Kobayashi, 1939 sensu Missarzhevsky always has a flattened or even slightly concave superperipheral part of the shell, the axial ribs are absent from the base. Thus, *P. lorenzi* Kobayashi, 1939 sensu Missarzhevsky should be described as a separate species. However, the same publication (Rozanov and Missarzhevsky, 1966, p. 103) contains a description of a new species, *Pelagiella adunca*, which is very similar to Siberian specimens of *"P. lorenzi."* The differences between these species mentioned in the comparison, i.e., the number of whorls (1.5 whorls in *P. adunca*, and up to 2 whorls in *"P. lorenzi"*), aperture shape (oval and wide in *P. adunca*, and narrower, subtriangular in *"P. lorenzi"*) closely correspond to the variability of pelagiellas (both ontogenetic and intraspecific[6]).

Probably, *"P. lorenzi"* represents only a more tightly coiled form of *P. adunca*. This assumption is strengthened by the fact, that *"P. lorenzi,"* illustrated by Missarzhevsky in one of his latest monographs (1989, pl. 8, figs. 6, 10), is identical to the holotype illustration of *P. adunca* (Rozanov and Missarzhevsky, 1966, pl. 9, figs. 1, 2).

V.V. Ermak (Ermak and Pel'man, 1986) described five species of the genus *Pelagiella* from the uppermost Atdabanian (uppermost *Judomia* Zone) of the Kharaulakh Range (northern part of the Siberian Platform), i.e., *P. lorenzi* Kobayashi, *P. adunca* Miss., *P. bentica* Ermak, *P. serpentis* Ermak, and *P. asymmetrica* Ermak. Three of these species were new. All of the species originate from a single rock sample. Three new species, *P. bentica, P. serpentis* and *P. asymmetrica*, represent different juvenile stages of the same species, while *"P. lorenzi"* and *P. adunca* are adult specimens, but indistinguishable from each other (see Ermak and Pel'man, 1986, pl. 26, figs. 3–8). Thus, I consider all of the specimens described by Ermak to be synonyms of *P. adunca* Miss.

*P. repinae* Vassiljeva, 1998 from the Atdabanian of the Siberian Platform (Erketek Formation, middle reaches of the Olenek River) is probably a synonym of the widely distributed Siberian species *P. adunca*, but the inadequate illustrations of *P. repinae* in the original description (Vassiljeva, 1998, p. 83, pl. 5, figs. 1, 2, 5) do not allow me to synonymize these species firmly.

A single specimen from the Transbaikalian collection (PIN, specimen no. 2019/1116; pl. 2, fig. 12) is an internal mold of the sinistral shell. This unique phenomena for the genus *Pelagiella*, which is always dextrally coiled, is an anomaly rarely occurring among other groups of primitive gastropods.

Occurrence. Lower Cambrian, Atdabanian and Botomian; Siberian Platform, Altai-Sayan fold belt, Eastern Transbaikalia.

Material. Several dozen shells and internal molds from the Uslon Section (sample nos. 7000/28, 7000/48, 7000/50, 7000/60, 7000/65, 7000/66, 7000/68, 7000/71, 7000/72, C-84/8, and 7000/81) and "Archaeocyathan Hill" Locality (sample nos. 18/4, C-84/4, 9000/2, 9000/7, and 9000/9).

[6] The ontogenetic and intraspecific variability of pelagiellids was shown for *P. subangulata* (Tate, 1892) and *P. madianensis* (Zhou et Xiao, 1984) (see Gravestock *et al.*, 2001, pls. 44–47).

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