

Archaeocyathids from the Atdabanian (Lower Cambrian) of the Altay-Sayan Foldbelt, Russia

Dena V. OSADCHAYA & Dmitriy V. KOTEL'NIKOV

All-Russian Geological Institute, Sredniy prospekt 74,
Saint Petersburg 199026 (Russia)

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ABSTRACT

The stratigraphic distribution of irregular archaeocyaths (archaeocyathids) species in the Atdabanian Stage of the Altay-Sayan Foldbelt is established. One assemblage characterizes the Bazaikha Superhorizon and two assemblages are observed in the Kameshki Horizon. These assemblages are consistent independently of the facies type and traceable throughout Batenevskiy Ridge (carbonate facies), Tuva (volcanic-carbonate facies) and Eastern Sayan (siliciclastic-carbonate facies). This observation confirms the existence of a single Altay-Sayan basin by the middle Atdabanian time. Three new species (*Loculicyathus voznesenskii*, *Mikhnoocyathus irregularis*, *Sakhacyathus karpinskiï*) are described and the most typical species are revised and redesci-
bed.

KEY WORDS
Archaeocyathida,
Atdabanian,
Altay-Sayan,
correlations.

RÉSUMÉ

Archéocyathes de l'Atdabanien (Cambrien inférieur) du massif plissé d'Altaï-Saïan, Russie. La répartition stratigraphique des archéocyathes irréguliers (archéocyathides) du massif plissé d'Altaï-Saïan est établie pour l'Atdabanien. Un assemblage caractérise le Superhorizon de Bazaikh et deux assemblages sont observés dans l'Horizon de Kameshki. Ces assemblages concordent, indépendamment du type de faciès, et peuvent se suivre à travers la crête de Batenev (faciès carbonaté), la région de Tuva (faciès volcano-carbonaté) et le Saïan oriental (faciès silicoclastique et carbonaté). Cette observation confirme l'existence d'un seul bassin dans l'Altaï-Saïan au milieu de l'Atdabanien. Trois nouvelles espèces sont décrites (*Loculicyathus voznesenskii*, *Mikhnoocyathus irregularis*, *Sakhacyathus karpinskiï*) ; les autres espèces sont révisées et redécrites.

MOTS CLÉS
Archeocyathida,
Atdabanien,
Altaï-Saïan,
corrélations.

INTRODUCTION

The Altay-Sayan Foldbelt is a mountainous region of Siberia (SW of the Siberian Platform). It includes Kuznetskiy Alatau, Batenevskiy Ridge, Altay Mountains, Shoriya Mountains, Eastern and Western Sayan and Tuva. Thick and continuous Lower Cambrian strata of the Altay-Sayan Foldbelt are, in addition to those of the Siberian Platform, a key sequence for the Lower Cambrian stage and zone subdivisions that are accepted in Russia; Botomian and Toyonian archaeocyathan zones are established here. However, these zones were entirely based on regular archaeocyaths whose geographic distribution is limited and, as a result, their significance for correlations.

Irregular archaeocyaths (archaeocyathids) of the Altay-Sayan Foldbelt were poorly known. Too many species were commonly and wrongly attributed to the genera "*Dictyocyathus*" and "*Loculicyathus*". Gravestock (1984) initiated new researches into the morphology of irregular archaeocyaths and this was expanded in the major book of Debrenne & Zhuravlev (1992). The work of the latter authors develops a new systematic of irregular archaeocyaths based on morphology, ontogeny and homologous variability; they provide a complete diagnosis, revised systematic affinities and an outline of stratigraphic distribution of all genera. There, we revise the Atdabanian irregular archaeocyath assemblages of the Altay-Sayan Foldbelt in the framework of this new systematics based on abundant material that we collected from Batenevskiy Ridge, Eastern Sayan and Tuva, mainly from the stratotypes of zones of the Bazaikha Superhorizon and Kameshki Horizon. These local subdivisions of the Altay-Sayan Foldbelt correspond to the Atdabanian Stage.

GEOLOGICAL SETTING

BATENEVSKIY RIDGE (SUKHIE SOLONTSY MASSIF)-CARBONATE SECTION TYPE
Calcimicrobial and calcimicrobial-archaeocyathan reefal carbonates dominate in the Batenevskiy Ridge. These are massive gray and

light gray limestones with unevenly spaced fossils. Irregular archaeocyaths are studied from the Solontsy Biohermal Massif in Sukhie Solontsy Valley, Tolcheya Village area (Fig. 1). The Solontsy Biohermal Massif spreads latitudinally for 8 km as a discontinuous belt of Lower Cambrian reefal limestones from 1000 to 1200 m in thickness. The Atdabanian strata are 600 m in thickness.

The *Nochorocyathus mariinskii* Zone is at the base of the Bazaikha Horizon in Batenevskiy Ridge. The most complete assemblage of this zone is derived from the reference section of Krutoy Log. Additional data are obtained from sections of 740.6 m, 786 m and 803.5 m altitudes. The *Nochorocyathus mariinskii* Zone is typified by genera *Cambrocyathellus*, *Neoloculicyathus*, *Dictyocyathus*, *Dictyosycon*, *Tabulacyathellus* and *Dictyofavus*. The most common species are *Cambrocyathellus communis* (Fonin), *C. similiseptus* (Voronin), *C. tuberculatus* (Vologdin), *C. kundatus* (Zhuravleva), *C. minutus* (Vologdin), *Neoloculicyathus primus* Voronin, *Loculicyathus membranivestites* Vologdin, *Dictyocyathus confertus* Fonin, *Archaeopharetra marginata* (Fonin), *Dictyosycon radiatus* (Zhuravleva), *Dictyofavus* sp., *D. lepidus* (Fonin), *D. obtusus* Gravestock, *Tabulacyathellus* sp. and *T. bidjaensis* Missarzhevskiy. Species of *Cambrocyathellus* are especially abundant at this level.

From the base of the following *Gordonicyathus howelli* Zone, the former archaeocyathan assemblage steadily declines. Single representatives of the earlier assemblage only exist at the top of the *Gordonicyathus howelli* Zone. In the lower part of this zone *Cambrocyathellus* sp., *C. communis*, *C. similiseptus*, *C. tuberculatus*, *C. kundatus*, *Neoloculicyathus primus*, *Loculicyathus membranivestites*, *Paranacyathus* ? sp., *Mikhnocyathus irregularis* Kotel'nikov n.sp., *Dictyocyathus confertus*, *Archaeopharetra marginata*, *Dictyosycon* sp., *Dictyofavus lepidus*, *Tabulacyathellus bidjaensis*, and *Kechikacyathus* ? sp. are present. *Cambrocyathellus neiburgianus* (Vologdin) appears in the upper part of the zone and *Loculicyathus membranivestites* becomes the most abundant species there (Fig. 2).

The same species is the only common archaeo-

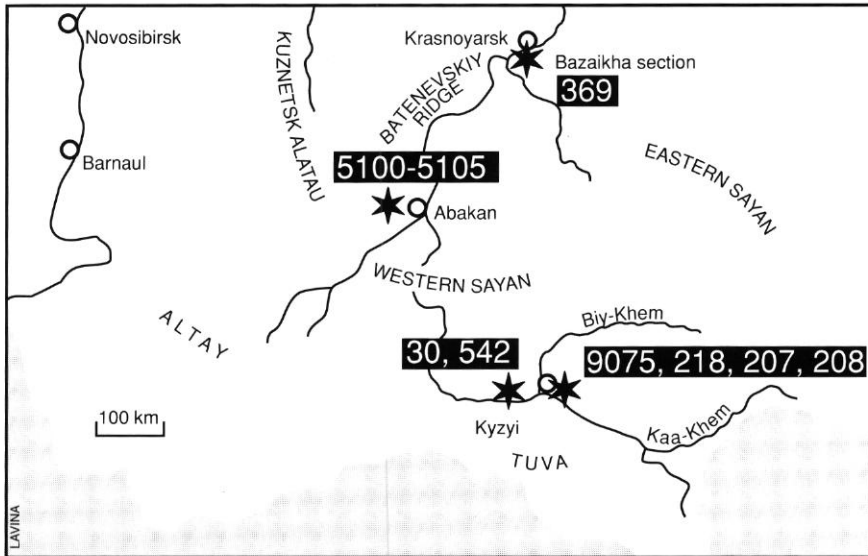


FIG. 1. — Situation of sections (Altay-Sayan Foldbelt, Russia). Localities **5100-5105**: Solontsy Biohermal Massif, Sukhie Solontsy Valley, Krutoy Log section, Batenevskiy Ridge; locality **369**: Bazaikha River section, Batenevskiy Ridge (Eastern Sayan); localities **30, 542**: Bayan Kol River section (Tuva); locality **9075**: Vadi Bala section; locality **218**: Terekyg Khem River section; localities **207, 208**: Tapsa river Basin, Il'chir River section (Central Tuva). Scale: 1/10 000 000.

cyathid of the Kameshki Horizon in the Krutoy Log and other sections of the Solontsy Biohermal Massif. Rare *Cambrocyathellus*, *Neoloculicyathus* and *Dictyocyathus* occur at the base of the horizon.

TUVA VOLCANIC-CARBONATE SECTION TYPE

Bayan Kol River Section

The Bayan Kol River is a left tributary of the Enisey River in Central Tuva. The reference section occurs in the lower course of the Bayan Kol River (Fig. 1). The lower subformation of the Bayan Kol Formation which thickness is 1100 m is of early Atdabanian age. On the left bank of the Bayan Kol River, the subformation includes sandstone-gravelstone-conglomerate unit with restricted red and light gray reefal limestones. Reefal limestones consist of kaliptra, kaliptrate bioherms, biohermal and biostromal beds.

The *Nochoroicyathus mariinskii* Zone of the Bazaikha Superhorizon is restricted to the basal red reefs and is characterized here by *Cambrocyathellus* sp., *C. tuberculatus*, *C. kundatus*, *Sakhacyathus karpinskii* Osadchaya et

Kotel'nikov n.sp., *Loculicyathus voznesenskii* Osadchaya et Kotel'nikov n.sp., *Archaeopharetra marginata*, *Dictyofavus lepidus*, and *Dictyocyathus confertus*. Modular forms of *Cambrocyathellus*, *Archaeopharetra* and *Dictyofavus* are common. *Cambrocyathellus* is the most diverse genus and *Archaeopharetra* dominates volumetrically.

Archaeocyathan assemblage of the *Gordonicyathus howelli* Zone is present in the upper gray reefs of the lower subformation. Only rare representatives of the earlier assemblage, *Cambrocyathellus tuberculatus*, *C. kundatus*, *Sakhacyathus karpinskii*, *Neoloculicyathus* ex gr. *primus*, and *Archaeopharetra marginata* are found. The Kameshki Horizon assemblage is not included in the present study.

Tapsa River Sections

The sections of the Tapsa River basin occur along the Vadi Bala Valley and Bol'shoy Il'chir Creek in the Cherbi Village area of the Taapsa and Kaa Khem rivers interfluvium, Central Tuva. The Il'chir Formation which is up to 2000 m in thickness, represents the Atdabanian Stage here. The lower

part of formation (200-700 m) contains lilac tuff-conglomerates, tuffgravelates, tuffits and tuffsandstones with scarce limestone lenses. The upper carbonate part of formation (700-1300 m) includes dark gray platy dolomitic limestones with marker beds of oolitic limestone, above which a reefal limestone with archaeocyaths occurs.

Vadi Bala Section. Archaeocyathan assemblage of the *Nochorocyathus mariinskii* Zone, Bazaikha Superhorizon, is restricted to a massive reefal limestone of the Vadi Bala Biohermal Massif and includes *Cambrocyathellus similiseptus*, *C. tuberculatus*, *C. minutus*, *Neoloculicyathus* sp., *Dictyocyathus* sp., *Archaeopharetra marginata*, *Dictyosycon radiatus* and *Dictyofavus lepidus*.

Bol'shoy Il'chir Creek Section. Archaeocyaths of the *Gordonicyathus howelli* Zone, Bazaikha Superhorizon, are found in white and red massive reefal limestone overlaying the basal tuffconglomerate. They are represented by *Cambrocyathellus* sp., *C. minutus*, *C. kundatus*, *Loculicyathus membranivestites*, *L. voznesenskii*, *Mikhnocyathus* ? sp., *Archaeopharetra marginata*, and *Tabulacyathellus* sp., among which *Loculicyathus membranivestites*, *L. voznesenskii* and *Mikhnocyathus* ? sp. appear at this level.

To the top of the Bol'shoy Il'chir Creek Section, along the creek upstream, archaeocyaths of the Kameshki Horizon are collected from limestone debris. These archaeocyaths are, *Cambrocyathel-*

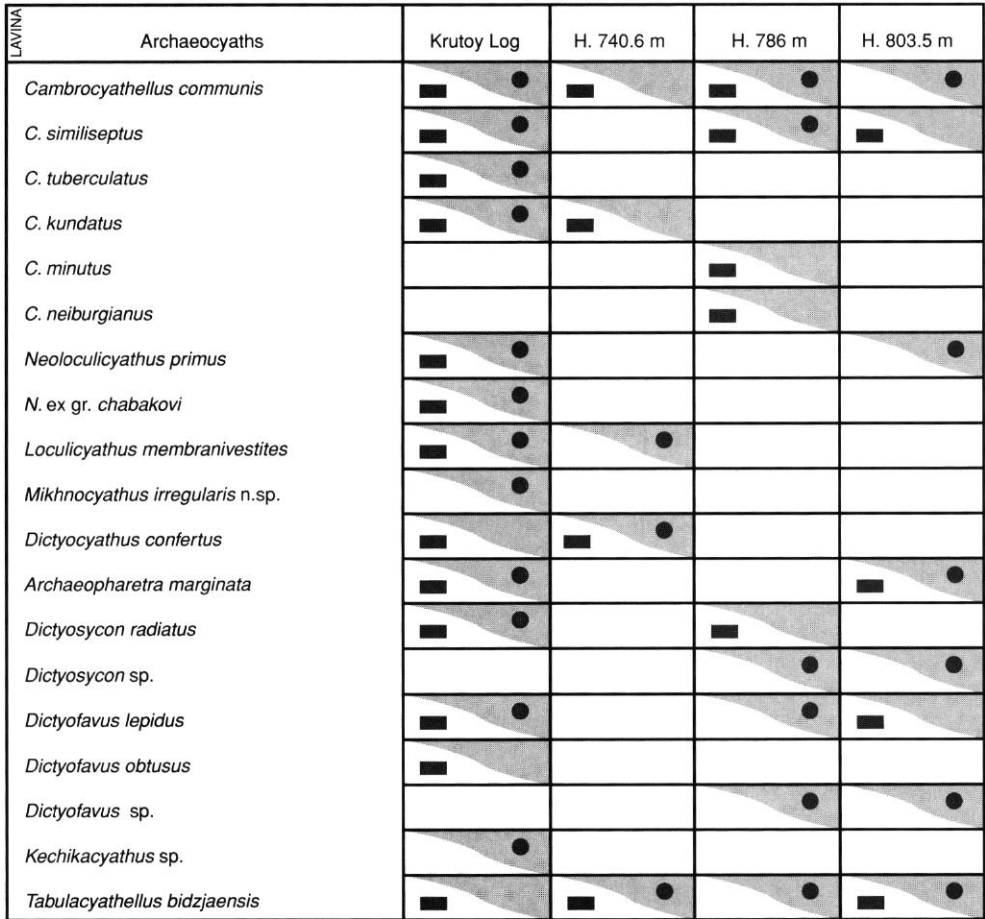


FIG. 2. — Distribution of Atdabanian irregular archaeocyath species in the Bazaikha Superhorizon of the Solontsy Biohermal Massif, Batenevskiy Ridge. Square, *Nochorocyathus mariinskii* Zone; circle, *Gordonicyathus howelli* Zone.

lus sp., *C. minutus*, *Loculicyathus membranivestites*, *L. tolli* Vologdin, *Mikhnocyathus irregularis* and *Dictyocyathus* sp. A similar assemblage occurs along the Terekyt Khem Creek of the Tapsa and Kaa Khem rivers interfluvium. This assemblage is distinctive in its abundance of branching *Cambrocyathellus minutus* and *Mikhnocyathus irregularis*.

Archaeocyathid assemblages of Tuva. Thus, the following irregular archaeocyath assemblages of the Atdabanian age are established in Tuva: Fourteen species of eight genera, *Cambrocyathellus*, *Neoloculicyathus*, *Loculicyathus*, *Sakhaocyathus*, *Dictyocyathus*, *Dictyofavus*, *Dictyosycon* and *Archaeopharetra* characterize the *Nochroiocyathus mariinskii* Zone of the Bazaikha Super-

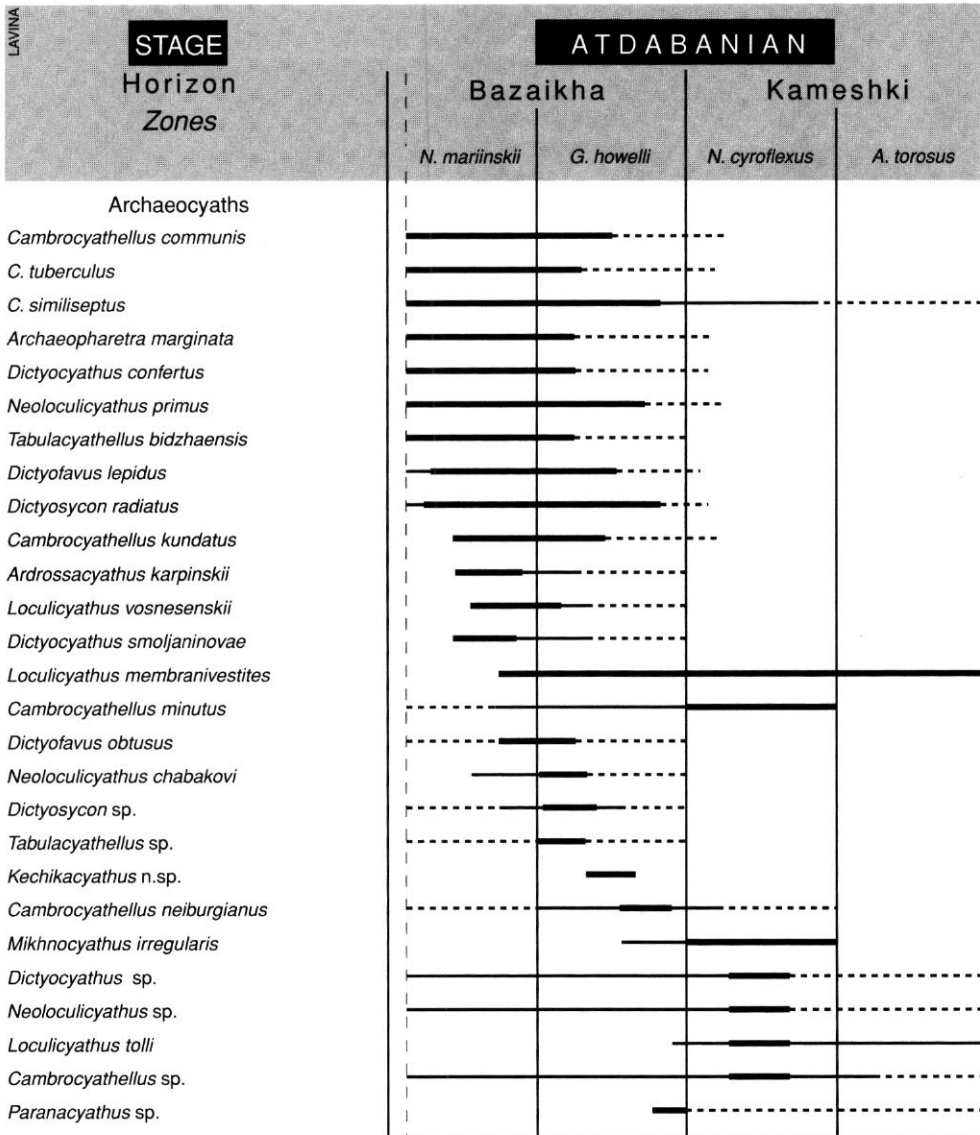


FIG. 3. — Distribution of Atdabanian irregular archaeocyath species in the Altay-Sayan Fold Belt.

horizon. This generic and specific association is almost identical to that of the Solontsy Biohermal Massif from the Batenevskiy Ridge. Species of *Cambrocyathellus* are especially diverse, and *Archaeopharetra marginata* dominates in abundance.

Nine species are known from the *Gordonicyathus howelli* Zone of the Bazaikha Superhorizon in Tuva: *Cambrocyathellus* sp., *C. minutus*, *C. tuberculatus*, *C. kundatus*, *Neoloculicyathus* ex gr. *primus*, *Loculicyathus membranivestites*, *L. voznesenskii*, *Archaeopharetra marginata* and *Tabulacyathellus* sp. *Loculicyathus* and *Tabulacyathellus* genera appear at this level for the first time.

Only six species have been found in the Kameshki Horizon: *Cambrocyathellus* sp., *C. minutus*, *Loculicyathus membranivestites*, *L. tolli*, *Mikhncyathus irregularis* and *Dictyocyathus* sp. The archaeocyathan species and generic diversity decreased at this level in Tuva, as well as in the Batenevskiy Ridge. In some sections of Tuva, *Cambrocyathellus minutus* and *Mikhncyathus irregularis* become very common.

EASTERN SAYAN SILICICLASTIC-CARBONATE

TYPE SECTION

Sections of the Bazaikha River

The Bazaikha River cuts the Cambrian strata in the Northwest of Eastern Sayan on the junction of the Altay-Sayan Foldbelt and the Siberian Platform, in the Torgashino Ridge. The Torgashino Massif which occurs in the Mana Depression has been proposed to be a large reefal massif (Zadorozhnaya 1983). The massif formed during the whole Early Cambrian and the beginning of Middle Cambrian. Atdabanian strata cropped out on the southern slope of the Torgashino Ridge, in the Kaltat River mouth area. The *Nochorocyathus mariinskii* Zone of the Bazaikha Superhorizon is restricted to the basal Bazaikha Member which consists of red limey sandstones, gravelites and limestones. Six genera of archaeocyathids are found in the member which include *Cambrocyathellus*, *Neoloculicyathus*, *Loculicyathus*, *Dictyofavus*, *Dictyosycon* and *Sakhacyathus*. The assemblage consists of twelve species which are *Cambrocyathellus* sp., *C. tuberculatus*, *C. neiburgianus*, *C. ex gr. similiseptus*, *Neoloculicyathus* sp., *N. primus*, *Sakhacyathus* sp.,

Loculicyathus membranivestites, *Dictyofavus lepidus*, *D. obtusus*, *Dictyosycon* sp. and *D. ex gr. radiatus*. There is striking similarity of this assemblage to the coeval ones discussed above. The only difference is an absence of species of *Dictyocyathus* and *Tabulacyathellus*.

The *Gordonicyathus howelli* Zone assemblage is restricted to the upper part of the siliciclastic-carbonate Bazaikha Member and the lower part of massive light gray reefal limestones of the Torgashino Formation. The same irregular archaeocyath association occurs here, namely *Cambrocyathellus* sp., *C. similiseptus*, *C. ex gr. kundatus*, *Neoloculicyathus* sp., *N. primus*, *N. ex gr. chabakovi Konyushkov*, *Loculicyathus membranivestites*, *Paranacyathus* ? sp., *Archaeopharetra* sp., *Dictyosycon* sp., *D. ex gr. radiatus* and *D. ex gr. gravis*. *Sakhacyathus*, *Dictyocyathus* and *Mikhncyathus* appear in the transitional beds to the Kameshki Horizon. Peculiarities of this assemblage consist in a diversity of *Neoloculicyathus* and *Dictyosycon* genera and almost complete absence of *Dictyofavus* which is abundant in the underlying strata.

CONCLUSIONS

The possibility to use archaeocyathid assemblages (instead of ajacyathid ones) for correlation of Early Cambrian strata in the Altay-Sayan Foldbelt is demonstrated here for the first time.

A constancy in the specific and generic composition of Atdabanian archaeocyathid assemblages through the Altay-Sayan Foldbelt is observed in spite of a facies difference between carbonates of the Batenevskiy Ridge, volcano-carbonates of Tuva and siliciclastic-carbonates of Eastern Sayan.

The *Nochorocyathus mariinskii* Zone assemblage declines steadily through the *Gordonicyathus howelli* Zone strata until an almost complete disappearance at the Bazaikha Superhorizon-Kameshki Horizon boundary. At the Bazaikha Superhorizon-Kameshki Horizon boundary, a notable shift in an archaeocyath composition is indicated. *Loculicyathus* dominates from the base of the Kameshki Horizon.

An identity of archaeocyathid assemblages in the Batenevskiy Ridge, Tuva and Eastern Sayan sug-

gests the existence of single basin during the Atdabanian epoch throughout the whole territory.

SYSTEMATIC PALEONTOLOGY

New and revised species are described in this section. Authors follow the systematics and terminology of irregular archaeocyaths (archaeocyathids) developed by Debrenne & Zhuravlev (1992). The figured type material is housed in the Muséum national d'Histoire naturelle (MNHN), Paris, France; other specimens are in the Central Scientific-Research Geological Exploring Museum (CNIGRm), Saint Petersburg, Russia. Other abbreviations include the Palaeontological Institute, Russian Academy of Sciences, Moscow, Russia (PIN) and the South Australian Museum, Adelaide, South Australia (SAM).

All dimensions are in millimetres.

Phylum PORIFERA Grant, 1872

Class ARCHAEOCYATHA

Bornemann, 1884

Order ARCHAEOCYATHIDA

Okulitch, 1935

Suborder LOCULICYATHINA

Zhuravleva, 1954

Superfamily LOCULICYATHOIDEA

Zhuravleva, 1954

Family LOCULICYATHIDAE Zhuravleva, 1954

Genus *Loculicyathus* Vologdin, 1931

Loculicyathus voznesenskii

Osadchaya *et* Kotel'nikov, n.sp.

(Fig. 4)

HOLOTYPE. — MNHN M810055 (Fig. 4); Central Tuva, Bayan Kol River, locality 542-1; Lower Cambrian, Atdabanian Stage, Bazaikha Superhorizon, *Nochoroicyathus mariinskii* Zone.

ETYMOLOGY. — The species is named after the geologist V. D. Voznesenskiy.

OTHER MATERIAL. — Three well-preserved specimens in transverse sections (CNIGRm).

DISTRIBUTION. — Bazaikha Superhorizon, Atdabanian Stage; Central Tuva.

DIAGNOSIS. — Species with funnel-shaped outer wall pores which pierce the wall in two rows per intersept; inner wall simple bearing spines.

DESCRIPTION

Cup diameter is up to 11.5. Outer wall simple, 0.15-0.2 thick, bearing two rows of funnel-shaped pores per intersept (pore diameter = 0.2-0.3, lintel width = 0.2). Intervallum (width = 2.5) contains pseudosepta which are pierced by five to seven pore rows (pore diameter = 0.2-0.3, pseudoseptum thickness = 0.1). Radial coefficient = 3.7, interseptal coefficient = 1:5-1:6. Inner wall simple (thickness = 0.2-0.25), with one pore row per intersept and spines (pore diameter = 0.4). Vesicles in the intervallum and pellicles on both walls are common.

DISCUSSION

This new species differs from *Loculicyathus membranivestites* Vologdin by less numerous pore rows per intersept of the outer wall (two against four), by funnel-shaped outer wall pores and by inner wall spines.

Genus *Cambrocyathellus* Zhuravleva, 1960

Cambrocyathellus similiseptus

(Voronin, 1979)

(Fig. 5)

Robustocyathus similiseptus Voronin, 1979: 99, pl. IX, fig. 1-3.

Cambrocyathellus similiseptus (Voronin) – Debrenne & A. Zhuravlev 1992: 122.

HOLOTYPE. — PIN 2404-11; Voronin, 1979, pl. IX, fig. 1; Western Mongolia, Khasagt Khairkhan Ridge; Lower Cambrian, Atdabanian Stage.

OTHER MATERIAL. — Twenty well-preserved specimens (CNIGRm).

DISTRIBUTION. — Bazaikha Superhorizon, Atdabanian Stage; Kuznetskiy Alatau, Batenevskiy Ridge, Tuva, Eastern Sayan, Mongolia.

DESCRIPTION

Cup diameter is up to 5-6. Outer wall simple of

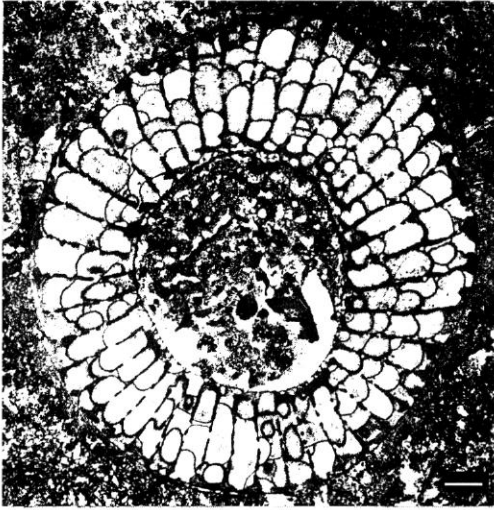


FIG. 4. — *Loculicyathus voznesenskii* Osadchaya et Kotel'nikov, n.sp., holotype MNHN M81005, transverse section, *Nochoroicyathus mariinskii* Zone, Bazaikha Superhorizon, Atdabanian Stage; locality 542-1, Bayan Kol River section, Central Tuva, Russia. Scale bar: 1 mm.

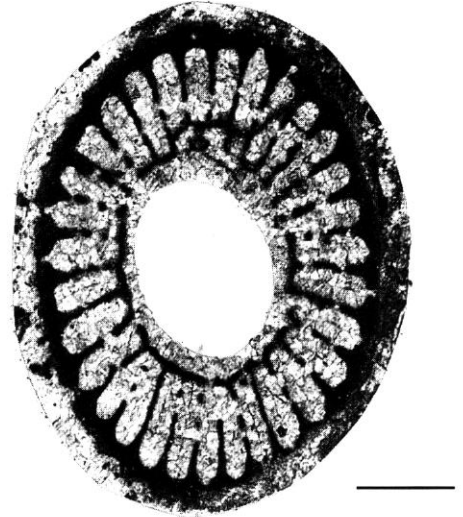


FIG. 5. — *Cambrocyathellus similiseptus* (Voronin), specimen CNIGRm 12917/4, transverse section, *Nochoroicyathus mariinskii* Zone, Bazaikha Superhorizon, Atdabanian Stage; locality 9075-2, Vadi Bala section, Central Tuva, Russia. Scale bar: 1 mm.

Cambrocyathellus-type, 0.1 thick, bearing a single row of rounded pores per intersept (pore diameter = 0.1). Intervallum (width = 1-1.5) is filled with pseudosepta which are pierced by four to five pore rows (pore diameter = 0.1, pseudoseptum thickness = 0.1). Radial coefficient = 7.5, intersept coefficient = 1:4. Inner wall simple, with one pore row per intersept (pore diameter = 0.15, wall thickness = 0.05). Vesicles are present in the intervallum.

DISCUSSION

Cambrocyathellus similiseptus differs from *C. tuberculatus* (Vologdin) by thicker pseudosepta (0.1 against 0.03) and by thinner inner wall (0.05 against 0.1).

Genus *Mikhncyathus* Maslov 1957

Mikhncyathus irregularis

Kotel'nikov, n.sp.
(Fig. 6)

HOLOTYPE. — MNHN M81006; Central Tuva, Tapsa River basin, Terektyg Khem River, locality 218; Lower Cambrian, Atdabanian Stage, Kameshki Horizon, *Nalivkinicyathus cyroflexus* Zone.

ETYMOLOGY. — *Irregularis* (Lat.) = irregular.

OTHER MATERIAL. — Fifty well-preserved specimens (CNIGRm).

DISTRIBUTION. — *Gordonicyathus howelli* Zone, Bazaikha Superhorizon-*Nalivkinicyathus cyroflexus* Zone, Kameshki Horizon, Atdabanian Stage; Batenevskiy Ridge, Tuva.

DIAGNOSIS. — Bowl-like cups; outer wall with numerous pore rows per intersept, highly porous pseudosepta and abundant plate tabulae.

DESCRIPTION

Cup diameter above 30. Outer wall simple of *Cambrocyathellus*-type, pierced by four to five rows of rounded pores per intersept (pore diameter = 0.07, lintel width = 0.1, wall thickness = 0.1). Intervallum of 1.5 in width, containing pseudosepta pierced by seven to ten pore rows (pseudoseptum thickness = 0.05, pore diameter 0.05), together with plate tabulae. Interseptal coefficient = 1:2-1:2.5. Tabulae are developed at different levels in adjacent intersepts, a single tabula may be continuous for two to three intersepts. Tabulae are convex, bearing five to six pore rows per intersept (pore diameter = 0.05-0.07,



FIG. 6. — *Mikhnocyathus irregularis* Kotel'nikov, n.sp.: **A**, holotype MNHN M81006, fragment of transverse section; **B**, paratype MNHN M81007, fragment of transverse section, *Nalivkinicyathus cyroflexus* Zone, Kameshki Horizon, Atdabanian Stage; locality 218, Terekyg Khem River section, Central Tuva, Russia. Scale bar: 1 mm.

tabula thickness = 0.05). Inner wall simple, with three to four pore rows per intersept (wall thickness = 0.07, pore diameter = 0.05). Vesicles are abundant in the intervallum.

DISCUSSION

This new species differs from *Mikhnocyathus zolaensis* Maslov by more numerous pore rows per intersept of the outer wall (four to five against three) and of pseudosepta (seven to ten against five to six), as well as by more abundant tabulae, few being present since juvenile stages (cup diameter = 3.5-9.5 with interseptal coefficient = 1:1-1:1.5 only).

Superfamily SAKHACYATHOIDEA
 Debrenne *et al.* Zhuravlev, 1990
 Family SAKHACYATHIDAE
 Debrenne *et al.* Zhuravlev, 1990

Genus *Sakhacyathus*
 Debrenne *et al.* Zhuravlev, 1990

Sakhacyathus karpinski
 Osadchaya *et al.* Kotel'nikov, n.sp.
 (Fig. 7)

HOLOTYPE. — MNHN M81008; Central Tuva, Bayan Kol River, locality 30-1; Lower Cambrian, Atdabanian Stage, Bazaikha Superhorizon.

ETYMOLOGY. — The species is named after the Academician A. P. Karpinskiy.

OTHER MATERIAL. — Five well-preserved specimens in transverse and oblique sections, MNHN M81007, paratypes in CNIGRM.

DISTRIBUTION. — Bazaikha Superhorizon, Atdabanian Stage; Central Tuva.

DIAGNOSIS. — Species with two outer wall pore rows per intersept.

DESCRIPTION

Modular sheet-like and solitary skeletons with a transverse folding. Outer wall pustular bearing two rows of pores per intersept (wall thickness = 0.15-0.20, pore diameter = 0.15-0.2, lintel width = 0.08-0.1). Intervallum (1-1.5 in width) contains non porous to sparsely porous pseudosepta (pore diameter = 0.1-0.12, thickness = 0.07-0.1). Interseptal coefficient = 1:3. Inner wall simple, 0.1-0.2 thick, with two to three pore rows per intersept (pore diameter = 0.1-0.2). Vesicles are present in the intervallum and a



FIG. 7. — *Sakhacyathus karpinskii* Osadchaya et Kotel'nikov, n.sp., holotype MNHN M81008, oblique transverse section of a modular form, *Nochorocyathus mariinskii* Zone, Bazaikha Superhorizon, Atdabanian Stage; locality 30-1, Bayan Kol River section, Central Tuva, Russia. Scale bar: 1 mm.

secondary thickening is developed in the lower part of the cup.

DISCUSSION

This new species differs from *Sakhacyathus sub-artus* (Zhuravleva) by more numerous pore rows per intersept of the outer wall (two against one).

Suborder ARCHAEOCYATHINA
Okulitch, 1935
Superfamily DICTYOCYATHOIDEA
Taylor, 1910
Family DICTYOCYATHIDAE
Taylor, 1910

Genus *Dictyocyathus* Bornemann, 1891

Dictyocyathus confertus Foinin, 1982
in Voronin et al. 1982
(Fig. 8)

Dictyocyathus confertus Foinin – Voronin et al. 1982: 94, pl. XXIII, fig. 7.

HOLOTYPE. — PIN 3302/360; Voronin et al. 1982, pl. XXIII, fig. 7; Western Mongolia, Khasagt Khairkhan Ridge, Salaany Gol River, locality N-226/290; Lower Cambrian, Atdabanian Stage, *Alataucyathus jaroshevitschi*-, *Tabulacyathellus bidzhaensis*-, *Pretiosocyathus subtilis* beds.

OTHER MATERIAL. — Ten well-preserved specimens (CNIGRm).

DISTRIBUTION. — Bazaikha Superhorizon-Kameshki Horizon, Atdabanian Stage; Batenevskiy Ridge, Tuva, Eastern Sayan, Mongolia.



FIG. 8. — *Dictyocyathus confertus* Fonin, specimen CNIGRm 12917/5, oblique transverse section, *Nochoroicyathus mariinskii* Zone, Bazaikha Superhorizon, Atdabanian Stage; locality 5101-3, Sukhie Solontsy Valley, Batenevskiy Ridge, Russia. Scale bar: 1 mm.

DESCRIPTION

Cup diameter is up to 7.3. Outer wall basic simple, 0.7 thick, bearing a single pore row per intersept (pore diameter = 0.12-0.15, lintel width = 0.5). Intervallum of 1.5 in width is filled with a dictyonal network. Taeniae are pierced by nine to ten vertical pore rows (pore diameter = 0.15-0.25, thickness of intervalar elements including taeniae and synapticalae = 0.03). Synapticalae are regularly arranged in six to eight rows per intervallum width. Radial coefficient = 12-13, interseptal coefficient = 1:10. Inner wall simple, with one pore row per intersept (pore diameter = 0.1).

DISCUSSION

Dictyocyathus confertus differs from other species of *Dictyocyathus* by thinner skeletal elements and by higher radial coefficient.

Superfamily ARCHAEOCYATHOIDEA

Hinde, 1889

Family ARCHAEOCYATHIDAE Hinde, 1889

Genus *Archaeopharetra*

R. Bedford *et* W. R. Bedford, 1936

Archaeopharetra marginata

(Fonin, 1982) *in* Voronin *et al.* 1982

(Fig. 9)

Salanicyathus marginatus Fonin – Voronin *et al.* 1982: 96, pl. XXIV, figs 1-3.

Salanicyathus ordinatus Fonin – Voronin *et al.* 1982: 97, pl. XXV, figs 1-3.

Salanicyathus disertus Fonin – Voronin *et al.* 1982: 98, pl. XXV, fig. 4.

Flindersicyathus gracilis Fonin – Voronin *et al.* 1982: 109, pl. XXXIII, figs 1-5.

Archaeopharetra marginata (Fonin) – Debrenne & A. Zhuravlev 1992: 121.

HOLOTYPE. — PIN 3302/368; Voronin *et al.* 1982, pl. XXIV, fig. 1; Western Mongolia, Khasagt Khaikhan Ridge, Salaany Gol River, locality N-224/180; Lower Cambrian, Atdabanian Stage, *Alataucyathus jaroshevitschi*-, *Tabulacyathellus bidzhaensis*-, *Pretiosocyathus subtilis* beds.

OTHER MATERIAL. — Ten well-preserved specimens CNIGRm.

DISTRIBUTION. — Bazaikha Superhorizon-Kameshki Horizon, Atdabanian Stage; Kuznetskiy Alatau, Batenevskiy Ridge, Central Tuva, Eastern Sayan, Mongolia.

DESCRIPTION

Cup diameter is up to 18. Outer wall centripetal, 0.1 thick. Two to three pore rows cross an intervalar cell which is formed by pseudotaenial lintels and synapticalae (pore diameter = 0.05-0.1). Intervallum of 1.5-2 in width bearing occasional segmented tabulae and porous pseudotaeniae pierced by five to six vertical pore rows (pore diameter = 0.25-0.35). Synapticalae are irregularly spaced in two to three elements per intervallum width. Radial coefficient = 12-14, interseptal coefficient = 1:4-1:5. Inner wall simple, with one pore row per intersept and spines (thickness = 0.05, pore diameter = 0.1-0.2).

DISCUSSION

Archaeopharetra marginata differs from *A. itma-*

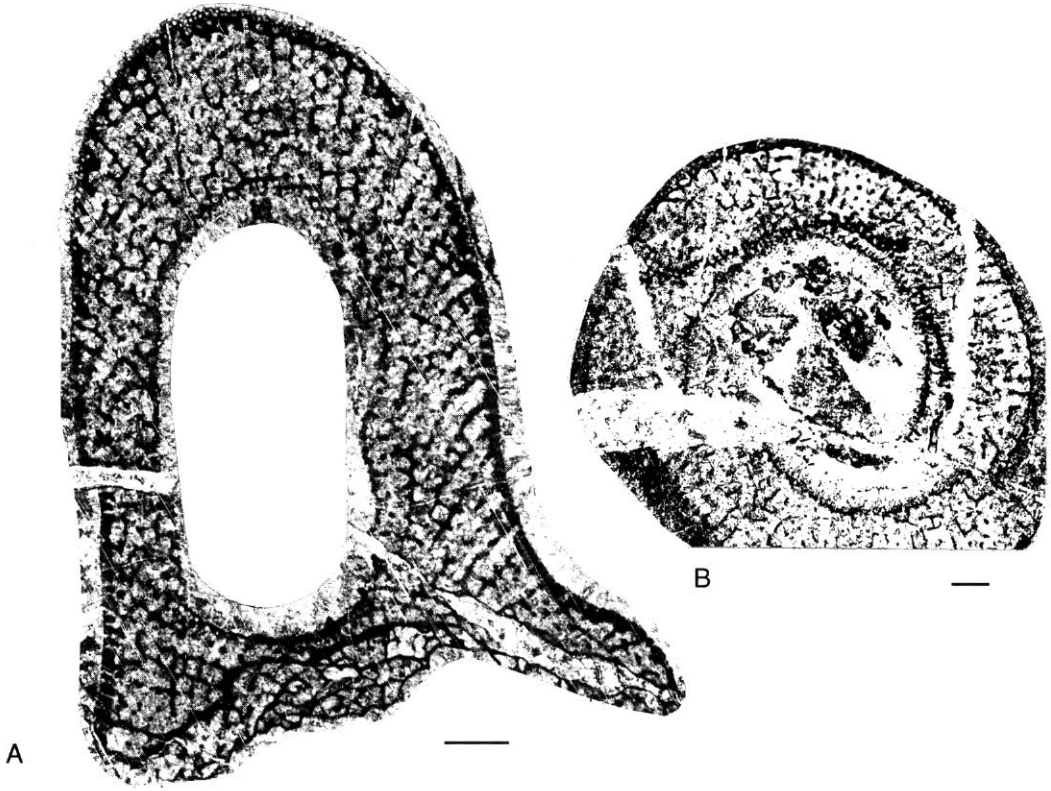


FIG. 9. — *Archaeopharetra marginata* (Fonin), **A**, specimen CNIGRm 12917/8, oblique longitudinal section, locality 9075-1, Vadi Bala section, Central Tuva; **B**, specimen CNIGRm 12917/9, transverse section, locality 5101-8, Sukhie Solontsy Valley, Batenevskiy Ridge; *Nochoroicyathus mariinskii* Zone, Bazaikha Superhorizon, Atdabanian Stage, Russia. Scale bars: 1 mm.

tiensis (Belyaeva) by higher radial coefficient (twelve to fourteen against six to seven) and by smaller diameter of outer wall pores; from *A. yarbili* (Rodionova) by thicker outer wall (0.1 against 0.04) and by less numerous synapticalae.

Dictyocyathus lepidus Fonin – Voronin *et al.* 1982: 93, pl. XXIII, figs 5-6.

Chouberticyathus lepidus (Fonin) – Debrenne & A. Zhuravlev 1992: 123.

Dictyofavus sp. – Debrenne & A. Zhuravlev 1992, pl. XXVIII, fig. 2.

Suborder DICTYOFAVINA Debrenne, 1991
 Superfamily DICTYOFAVOIDEA
 Debrenne *et al.* Zhuravlev, 1992
 Family DICTYOFAVIDAE
 Debrenne *et al.* Zhuravlev, 1992

HOLOTYPE. — PIN 3302/358; Voronin *et al.* 1982, pl. XXIII, fig. 5; Western Mongolia, Khasagt Khaikhan Ridge, Salaany Gol River, locality F-13; Lower Cambrian, Atdabanian Stage, *Alataucyathus jaroshevitschi*-, *Tabulacyathellus bidzhaensis*-, *Pretiosocyathus subtilis* beds.

Genus *Dictyofavus* Gravestock, 1984

OTHER MATERIAL. — Twenty well-preserved specimens (CNIGRm).

Dictyofavus lepidus (Fonin, 1982)
 in Voronin *et al.* 1982
 (Fig. 10)

DISTRIBUTION. — Bazaikha Superhorizon-Kameshki Horizon, Atdabanian Stage; Batenevskiy Ridge, Central Tuva, Eastern Sayan, Mongolia.