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Cribricyaths and Microfossils of Uncertain  
Affinity Resembling Cribricyaths

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# PART E, REVISED, VOLUME 4, CHAPTER 20B: CRIBRICYATHS AND CALCAREOUS MICROFOSSILS OF UNCERTAIN AFFINITY RESEMBLING CRIBRICYATHS

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Cribricyaths were first described by VOLOGDIN (1932), who interpreted them as archaeocyathan larvae. In a subsequent monograph, VOLOGDIN (1964) treated cribricyaths as a class within the phylum Archaeocyatha.

VOLOGDIN (1966, p. 16) defined the class Cribricyatha as having “cups elongate or isometric, one-walled and two-walled. Walls built by transversely oriented ribbon-like platy elements (peripteratae) connected by longitudinal rodlike skeletal elements (baculi).” He compared cribricyaths with one-walled archaeocyaths and considered them to be the descendants of the latter. According to him, the peripterate construction of the wall was a further development of the archaeocyathan perforated wall, wherein pores are confined to tightly constrained horizontal files.

Cribricyaths are small (up to 2 cm in length and 1–2 mm in transverse section), cornute, bilaterally symmetric calcareous fossils, either one walled or two walled. In transverse section they are circular to elliptical, cardioid, or quadrate (subtetragonal). The outer wall consists of ribbonlike elements (peripterates), about 0.1 mm thick, spirally coiled along the cup axis (Fig. 1). External surfaces of peripterates can be covered by longitudinal rodlike elements (baculi). The inner wall, if present, is eccentric, fused to one (usually the concave) side of the outer wall. It is porous and consists of transverse, platelike elements (striae) or

can be contiguous. Longitudinal lintels may additionally be present.

JANKAUSKAS (1969, 1972) showed that cribricyath ontogenetic development commenced from a nonporous cup 0.03–0.04 mm in diameter. The inner wall appeared after the complication of the outer wall.

Cribricyath skeletal microstructure is microgranular, similar to that of archaeocyaths (ZHURAVLEVA & OKUNEVA, 1981; ROZANOV & SAYUTINA, 1982). However, the microgranule size (about 2.0  $\mu\text{m}$ ) is smaller than the microgranules constituting archaeocyaths from the same locality (KRUSE & DEBRENNE, 1989). As with archaeocyaths, the microstructural type implies a primary magnesium calcite skeletal mineralogy.

Cribricyath affinities are still a matter of debate. BOYARINOV (1962) suggested that they were ancestral to conulariids because some cribricyaths have a quadrate transverse section. JANKAUSKAS (1972) considered them to be a separate metazoan phylum, whereas ZHURAVLEVA and OKUNEVA (1981), BELYAEVA (1985), ZHURAVLEVA and MYAGKOVA (1987), and BELYAEVA and ZHURAVLEVA (1990) maintained that cribricyaths are simply outgrowths of archaeocyathan cups, similar to some archaeocyathan secondary skeletal structures, or even a specialized mode of archaeocyathan existence somewhat analogous to sporophytes and gametophytes in higher plants. However, evidence

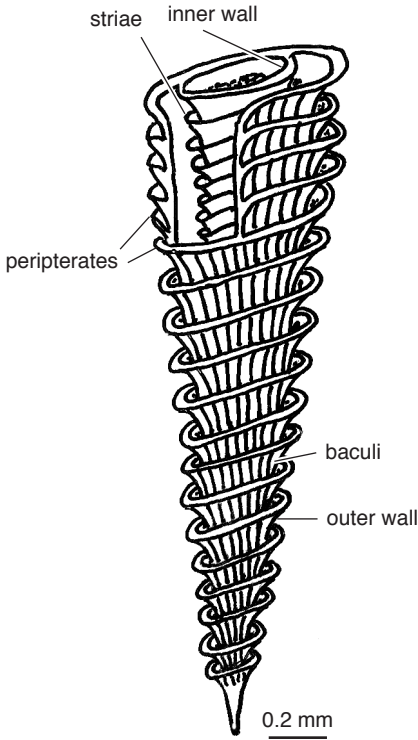


FIG. 1. Reconstruction of cribricyathan skeleton as loosely exemplified by *Dolichoocyathus* VOLOGDIN, based on etched and thin-sectioned specimens, Tuva, Russia, external longitudinal view,  $\times 10$  (Zhuravlev, new).

for the consistent co-occurrence of any pair or set of archaeocyathan and cribricyathan taxa is lacking. Furthermore, cribricyathans were much more restricted in space and time than were archaeocyathans.

Cribricyathans were sessile reef dwellers, and befitting their tiny size, mostly crypto-bionts (ZHURAVLEV & WOOD, 1995). Cribricyathan habitats were restricted to areas of constant water currents, presumably necessary for filter feeding (WOOD, ZHURAVLEV, & CHIMED TSEREN, 1993). Possibly, some were ectoparasites on archaeocyathans, as their settlement on archaeocyathan skeletons commonly caused malformation of the host (DEBRENNE & ZHURAVLEV, 1992).

The earliest cribricyathans are known from the middle Tommotian of East Sayan. During the Atdabanian and Botoman, they

became widespread along the entire Ural-Mongolian Foldbelt (Urals, Altay Sayan, Tuva, Mongolia, Transbaikalia, and Russian Far East). They are unknown beyond the limits of this region, with the exception of a single Atdabanian species from the Siberian Platform (SUNDUKOV & ZHURAVLEV, 1989).

The pioneering cribricyathan systematics of VOLOGDIN (1964, 1966) were reworked by JANKAUSKAS (1965, 1969; VOLOGDIN & JANKAUSKAS, 1968) based on rich material from mixed siliciclastic-carbonate rocks of the Krasnoyarsk region (East Sayan). He described a large new group, order Pterocyathida, and later (JANKAUSKAS, 1972, 1973) introduced a morphological key to all cribricyathan genera. Through synonymization, he also significantly reduced the number of formal genera having diagnoses based only on single sections. With necessary nomenclatural corrections, his systematics serves as the basis for the present revision.

The following taxonomic criteria, listed with their known character states, are adopted here:

- Order: baculi [absent/present]
- Superfamily: cup [one/two]-walled
- Family: peripterates [closed/open]
- Genus: transverse section [circular to elliptical/cardioid/quadrate]
- Peripterates [weakly/well] developed
  - If well developed: Peripterates open [internally/externally]
- Inner wall [contiguous/of striae]
  - If of striae: Striae [planar/curved]

## Class CRIBRICYATHA Vologdin, 1961

[*nom. correct.* ZHURAVLEV & KRUSE, herein, *pro* Cribricyathae VOLOGDIN, 1964, p. 1392, *nom. correct. pro* Cribricyathae VOLOGDIN, 1961, p. 177] [=Protoarchaeocyatha RADUGIN, 1964, footnote, p. 145; =phylum Cribricyatha JANKAUSKAS, 1972, p. 166, *nom. correct.* ZHURAVLEVA & OKUNEVA, 1981, p. 23, *pro* Cribricyathi JANKAUSKAS, 1972, p. 166]

One- or two-walled cornute, bilaterally symmetric aporose cups of circular, elliptical, cardioid, or quadrate (subtetragonal) transverse section; outer wall of ribbonlike peripterates coiled along cup axis to form a spiral chamber that can be either closed or open externally or internally; longitudinal,

rodlike baculi may be present on external surface of peripterates; inner wall, if present, is excentric, fused to outer wall on one side, and consists of transverse annular platelike striae or may be a contiguous porous sheet; original magnesium calcite skeletal mineralogy. *lower Cambrian (Tom.2–Bot.3)*.

## Order VOLOGDINOPHYLLIDA Radugin, 1964

[*nom. correct.* HILL, 1972, p. 137, *pro* order Vologdinophylloidea RADUGIN, 1964, p. 145] [=order Akademiophylloidea RADUGIN, 1964, p. 145; =Pterocyathida JANKAUSKAS, 1969, p. 134, *nom. correct pro* order Pterocyathidae JANKAUSKAS, 1965, p. 439]

Baculi absent. *lower Cambrian (Tom.2–Bot.1)*.

### Superfamily VOLOGDINOPHYLLOIDEA Radugin, 1964

[*nom. correct.* ZHURAVLEV & KRUSE, herein, *pro* Vologdinophylloidea JANKAUSKAS, 1969, p. 134, *nom. transl. ex* Vologdinophylloidea RADUGIN, 1964, p. 145]

Cup one-walled. *lower Cambrian (Tom.2–Bot.1)*.

### Family VOLOGDINOPHYLLIDAE Radugin, 1964

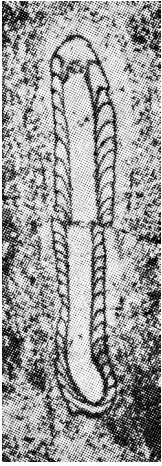
[Vologdinophylloidea RADUGIN, 1964, p. 145] [=Eophyllidae RADUGIN, 1966, p. 46; =Monophyllidae RADUGIN, 1966, p. 62; =Costophyllidae RADUGIN, 1966, p. 65; =Anomalophyllidae RADUGIN, 1966, p. 67; =Nefrophyllidae RADUGIN, 1966, p. 68; =Cardiophyllidae RADUGIN, 1966, p. 77; =Polygonophyllidae RADUGIN, 1966, p. 91, *nom. nud.*, invalid family-group name based on unavailable type genus; =Linzophyllidae RADUGIN, 1966, p. 97; =Kaphyllidae RADUGIN, 1966, p. 100]

Peripterates closed. *lower Cambrian (Atd.1)*.

**Vologdinophyllum** RADUGIN, 1962, p. 8 [\**V. chachlovi*; OD; holotype, RADUGIN, 1962, fig. 1; RADUGIN, 1964, fig. 1(37), 36-r 12, TPI, Tomsk] [= *Ophyllum* RADUGIN, 1964, p. 146, *nom. nud.*; = *Miophyllum* RADUGIN, 1964, p. 146, *nom. nud.*; = *Mesophyllum* RADUGIN, 1964, p. 146, *nom. nud.*, non SCHLÜTER, 1889, p. 325, cnidarian; = *Ellipsophyllum* RADUGIN, 1964, p. 146, *nom. nud.*; = *Nefrophyllina* RADUGIN, 1964, p. 146, *nom. nud.*; = *Nefrophyllum* RADUGIN, 1964, p. 146, *nom. nud.*; = *Dephyllum* RADUGIN, 1964, p. 146, *nom. nud.*; = *Laphyllum* RADUGIN, 1964, p. 146, *nom. nud.*; = *Unicophyllum* RADUGIN, 1964, p. 146, *nom. nud.*; = *Costophyllum* RADUGIN, 1964, p. 146, *nom. nud.*; = *Kaphyllum* RADUGIN, 1964, p. 146, *nom. nud.*; ? = *Trapecephyllum* RADUGIN, 1964, p. 146, *nom. nud.*; ? = *Quadriphyllum* RADUGIN, 1964, p. 146, *nom. nud.*; = *Rhombophyllina* RADUGIN, 1964, p. 146, *nom. nud.*; = *Rhombophyllum* RADUGIN, 1964,

p. 146, *nom. nud.*; = *Linzophyllum* RADUGIN, 1964, p. 146, *nom. nud.*; = *Vandophyllum* RADUGIN, 1964, p. 146, *nom. nud.*; = *Tephyllum* RADUGIN, 1964, p. 146, *nom. nud.*; = *Esphyllum* RADUGIN, 1964, p. 146, *nom. nud.*; = *Ellipsophyllina* RADUGIN, 1964, p. 146, *nom. nud.*; = *Eophyllum* RADUGIN, 1964, p. 146, *nom. nud.*; = *Anomalophyllum* RADUGIN, 1964, p. 146, *nom. nud.*; ? = *Longaevus* JANKAUSKAS, 1965, p. 439, *nom. nud.*; ? = *Crispus* JANKAUSKAS, 1965, p. 439, *nom. nud.*, all invalid genus-group names based on unavailable type species; = *Eophyllum* RADUGIN, 1966, p. 47 (type, *E. falciforme*, OD); = *Circophyllum* RADUGIN, 1966, p. 52, *nom. nud.*, non LANG & SMITH, 1939, p. 153, cnidarian; = *Hemiphyllina* RADUGIN, 1966, p. 53 (type, *H. prima*, OD); = *Hemiphyllum* RADUGIN, 1966, p. 54 (type, *H. semicircularae*, OD), non TOMES, 1887, p. 98, rugose coral; = *Hemiphyllum (Paraphyllum)* RADUGIN, 1966, p. 56 (type, *H. (P.) cerskii*, OD), non *Paraphyllum* HANCOCK, 1913, p. 40, orthopteran; = *Miophyllum* RADUGIN, 1966, p. 57 (type, *M. biconvexum*, OD); = *Ophyllum* RADUGIN, 1966, p. 58 (type, *O. planiconvexum*, OD); = *Mesophyllum* RADUGIN, 1966, p. 59 (type, *M. ordinare*, OD), non SCHLÜTER, 1889, p. 325, cnidarian; = *Ellipsophyllina* RADUGIN, 1966, p. 61 (type, *E. prima*, OD); = *Monophyllum* RADUGIN, 1966, p. 62 (type, *M. obrucevi*, OD), non FOMICHEV, 1953, p. 110, cnidarian; = *Vandophyllum* RADUGIN, 1966, p. 64 (type, *V. khalfini*, OD); = *Costophyllum* RADUGIN, 1966, p. 66 (type, *C. nalivkini*, OD); = *Anomalophyllum* RADUGIN, 1966, p. 67 (type, *A. karpinskii*, OD); = *Dephyllum* RADUGIN, 1966, p. 69 (type, *D. tadasi*, OD); = *Laphyllum* RADUGIN, 1966, p. 71 (type, *L. ordinare*, OD); = *Nefrophyllum* RADUGIN, 1966, p. 74 (type, *N. cairkini*, OD); = *Ellipsophyllum* RADUGIN, 1966, p. 87 (type, *E. typicum*, OD); ? = *Quadriphyllum* RADUGIN, 1966, p. 91 (type, *Q. koptevi*, OD); ? = *Trapecephyllum* RADUGIN, 1966, p. 93 (type, *T. unicum*, OD); = *Rhombophyllum* RADUGIN, 1966, p. 95 (type, *R. flexuosum*, OD); = *Linzophyllum* RADUGIN, 1966, p. 97 (type, *L. asymmetricum*, OD); = *Gonophyllum* RADUGIN, 1966, p. 99 (type, *G. zhuravlevae*, OD); = *Kaphyllum* RADUGIN, 1966, p. 101 (type, *K. irregulare*, OD); = *Tephyllum* RADUGIN, 1966, p. 102 (type, *T. mirabile*, OD); = *Esphyllum* RADUGIN, 1966, p. 103 (type, *E. originale*, OD), for discussion, see JANKAUSKAS (1969, p. 141); ? = *Longaevus* JANKAUSKAS, 1969, p. 144 (type, *L. vitalis*, OD); ? = *Crispus* JANKAUSKAS, 1969, p. 145 (type, *C. subdimidiatus*, OD)]. Transverse section circular to elliptical; peripterates well developed. *lower Cambrian (Atd.1)*: Altay Sayan.—FIG. 2, 1. \**V. chachlovi*, Ungut Formation, Atdabanian, Kolba River, Mana River, East Sayan, Altay Sayan, Russia, holotype, TPI 36-r 12, longitudinal section, ×10 (Radugin, 1962).

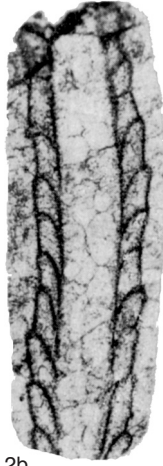
**Manaella** JANKAUSKAS, 1964 (April), p. 57 [\**M. basaiica*; OD; holotype, JANKAUSKAS, 1964, pl. 1, a, thin section 187/62, Division of General Geology, TPI, Tomsk; = *Cardiophyllum kelleri* RADUGIN, 1964 (January), p. 146, *nom. nud.*; = *Cardiophyllina*



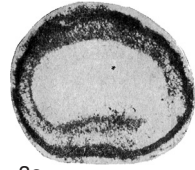
1 Vologdinophyllum



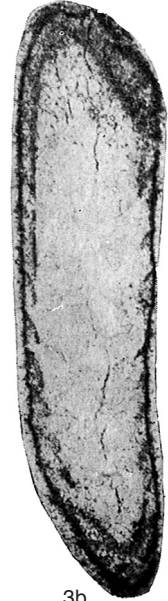
2a  
Manaella



2b



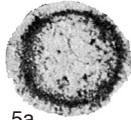
3a



3b  
Leibaella



4  
Dubius



5a



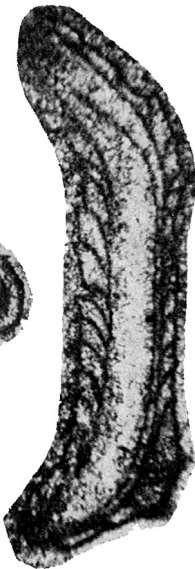
5b  
Ramifer



5c



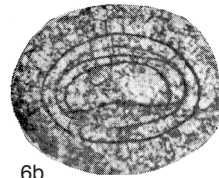
7a  
Erphyllum



7b



6a



6b  
Akademiophyllum

FIG. 2. Vologdinophyllidae, Leibaellidae, and Akademiophyllidae (p. 3–6).



*mani* RADUGIN, 1964 (January), p. 146, *nom. nud.*; =*Stapephyllum cerskii* RADUGIN, 1964 (January), p. 146, *nom. nud.*; =*Aphyllum lomonosovi* RADUGIN, 1964 (January), p. 146, *nom. nud.*; =*Cephyllum costatum* RADUGIN, 1964 (January), p. 146, *nom. nud.*; =*Bephyllum lermontovae* RADUGIN, 1964 (January), p. 146, *nom. nud.*; [= *Cardiophyllum* RADUGIN, 1964 (January), p. 146, *nom. nud.*; = *Cardiophyllina* RADUGIN, 1964 (January), p. 146, *nom. nud.*; = *Stapephyllum* RADUGIN, 1964 (January), p. 146, *nom. nud.*; = *Aphyllum* RADUGIN, 1964 (January), p. 146, *nom. nud.*, *non Aphyllum* SOSHKINA, 1937, p. 45, cnidarian; = *Cephyllum* RADUGIN, 1964 (January), p. 146, *nom. nud.*; = *Bephyllum* RADUGIN, 1964 (January), p. 146, *nom. nud.*, all invalid genus-group names based on unavailable type species; = *Cardiophyllina* RADUGIN, 1966, p. 77 (type, *C. manae*, OD); = *Cardiophyllum* RADUGIN, 1966, p. 79 (type, *C. kelleri*, OD); = *Stapephyllum* RADUGIN, 1966, p. 81 (type, *S. cerskii*, OD); = *Bephyllum* RADUGIN, 1966, p. 82 (type, *B. lermontovae*, OD); = *Cephyllum* RADUGIN, 1966, p. 84 (type, *C. costatum*, OD); = *Aphyllum* RADUGIN, 1966, p. 85 (type, *Aphyllum lomonosovi*, OD), *non* SOSHKINA, 1937, p. 45, cnidarian, for discussion, see JANKAUSKAS (1969, p. 143)]. Transverse section cardioid; peripterates well developed. *lower Cambrian (Atd.1)*: Altay Sayan.—FIG. 2, 2a–b. \**M. basaika*, Bazaikha Formation, Atdabanian, Bazaikha River, East Sayan, Russia; *a*, specimen TPI thin section 318, transverse section, ×40; *b*, specimen TPI thin section 239, longitudinal section, ×20 (Jankauskas, 1965).

### Family LEIBAELLIDAE Jankauskas, 1965

[Leibaellidae JANKAUSKAS, 1965, p. 439]

#### Peripterates open. *lower Cambrian (Tom.2–Bot.1)*.

**Leibaella** JANKAUSKAS, 1964, p. 58 [\**L. elovica*; OD; holotype, JANKAUSKAS, 1964, pl. 1, *k*; JANKAUSKAS, 1969, pl. 43, 8, collection 5, thin section 68, specimen 3, Division of General Geology, TPI, Tomsk; = *L. unguica* JANKAUSKAS, 1964, p. 59; for discussion, see JANKAUSKAS (1969, p. 138)]. Transverse section circular to elliptical; peripterates well developed, open internally. *lower Cambrian (Tom.4–Atd.3)*: Altay Sayan, Mongolia.—FIG. 2, 3a–b. \**L. elovica*, Ungut Formation, Atdabanian, Mana River, East Sayan, Altay Sayan, Russia; *a*, holotype, TPI collection 5, thin section 68, specimen 3, transverse section, ×20; *b*, paratype, TPI collection 5, thin section 65, specimen 4, longitudinal section, ×20 (Jankauskas, 1969).

**Dubius** JANKAUSKAS, 1969, p. 135 [\**D. uncatus*; OD; holotype, JANKAUSKAS, 1969, fig. 11a, pl. 43, 2, collection 5, thin section 142/63, specimen 1, TPI, Tomsk]. Transverse section circular to elliptical; peripterates weakly developed. *lower Cambrian (Tom.3–Bot.1)*: Altay Sayan, Mongolia.—FIG.

2, 4. \**D. uncatus*, Ungut Formation, Atdabanian, Mana River, East Sayan, Altay Sayan, Russia, holotype, TPI collection 5, thin section 142/63, specimen 1, longitudinal section, ×20 (Jankauskas, 1969).

**Ramifer** JANKAUSKAS, 1969, p. 136 [\**R. giratus*; OD; holotype, JANKAUSKAS, 1965, fig. 1 (1), JANKAUSKAS, 1969, fig. 12, pl. 43, 3, collection 5, thin section 265, specimen 2, TPI, Tomsk] [= *Ramifer* JANKAUSKAS, 1965, p. 439, *nom. nud.*, invalid genus-group name based on unavailable type species]. Transverse section circular to elliptical; peripterates well developed, open externally. *lower Cambrian (Tom.2–Atd.4)*: Altay Sayan, Mongolia.—FIG. 2, 5a–c. \**R. giratus*, Ungut Formation, Atdabanian, Mana River, East Sayan, Altay Sayan, Russia; *a*, paratype, TPI collection 5, thin section 261, specimen 5, transverse section, ×20; *b*, paratype, TPI collection 5, thin section 261, specimen 8, transverse section, ×20; *c*, holotype, TPI collection 5, thin section 265, specimen 2, longitudinal section, ×20 (Jankauskas, 1969).

## Superfamily AKADEMIOPHYLLOIDEA Radugin, 1964

[*nom. correct.* ZHURAVLEV & KRUSE, herein, *pro* Akademiophyllacea HILL, 1972, p. 139, *nom. transl. ex* Akademiophyllidae RADUGIN, 1964, p. 145] [= Striatocyathacea VOLOGDIN & JANKAUSKAS, 1968, p. 200, *nom. transl.* JANKAUSKAS, 1972, p. 177, *ex* Striatocyathidae VOLOGDIN & JANKAUSKAS, 1968, p. 200; = Pterocyathacea JANKAUSKAS, 1969, p. 146]

Cup two-walled. *lower Cambrian (Atd.1–Bot.1)*.

### Family AKADEMIOPHYLLIDAE Radugin, 1964

[Akademiophyllidae RADUGIN, 1964, p. 145] [= Pterocyathidae JANKAUSKAS, 1965, p. 440, *nom. nud.*, invalid family-group name based on unavailable genus name; = Academiophyllidae RADUGIN, 1966, p. 105, *nom. null.*; = Erphyllidae RADUGIN, 1966, p. 107; = Pterocyathidae JANKAUSKAS, 1969, p. 146]

Peripterates closed. *lower Cambrian (Atd.1–Bot.1)*.

**Akademiophyllum** RADUGIN, 1964, p. 145 [\**A. corniforme*; OD; holotype, RADUGIN, 1964, fig. on p. 147, RADUGIN, 1966, pl. 7, 39, collection 61r, specimen 8-100-34, TPI, Tomsk] [= *Akademiophyllum* JANKAUSKAS, 1965, p. 440, *nom. nud.*; = *Lacerathus* JANKAUSKAS, 1965, p. 440, *nom. nud.*; = *Pterocyathus* JANKAUSKAS, 1965, p. 440, *nom. nud.*, all invalid genus-group names based on unavailable type species; = *Academiophyllum* RADUGIN, 1966, p. 106, *lapsus calami pro* *Akademiophyllum* RADUGIN, 1964, p. 145; = *Laceratus* JANKAUSKAS, 1969, p. 149 (type, *L. cuneatus*, OD); = *Pterocyathus* JANKAUSKAS, 1969, p. 150 (type, *P. glausus*, OD)]. Transverse section circular to elliptical; peripterates well developed; inner wall contiguous. *lower Cambrian (Atd.1–Bot.1)*: Altay Sayan, Mongolia,

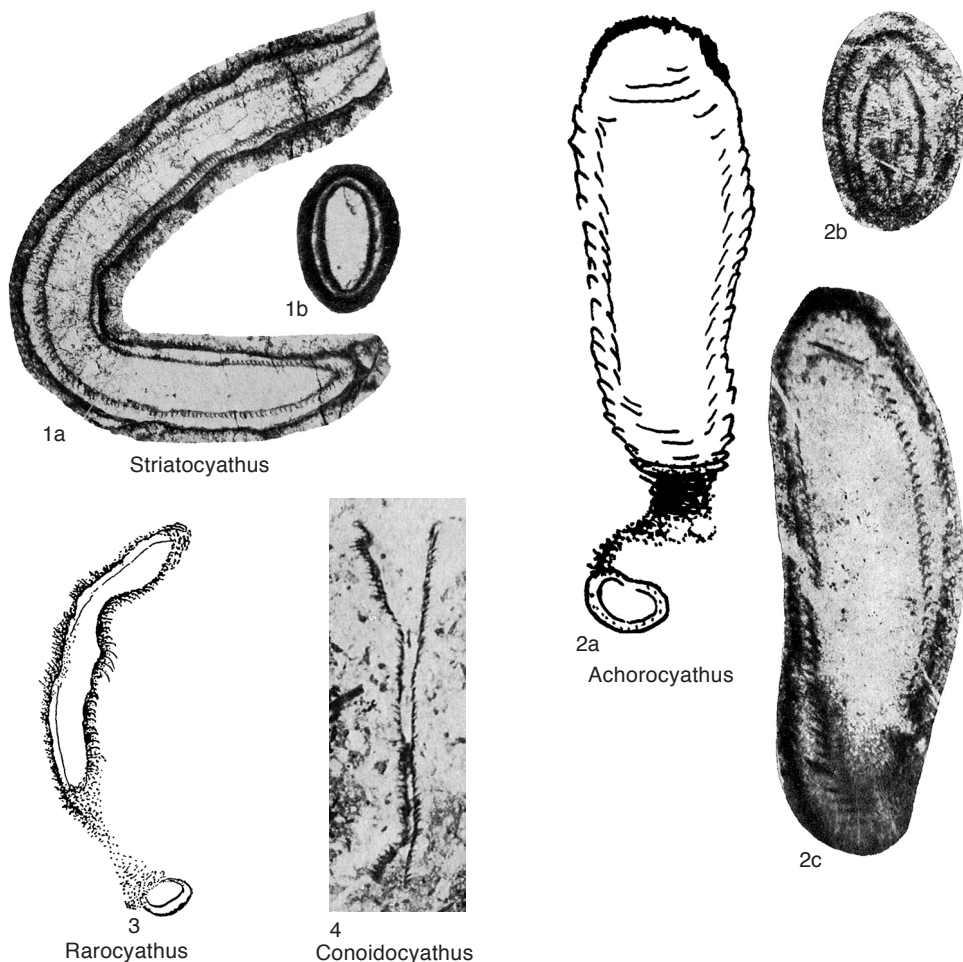


FIG. 3. Striatocyathidae and Conoidocyathidae (p. 6–7).

Far East.—FIG. 2, 6a–b. \**A. cornuforme*, Ungut Formation, Atdabanian, Mana River, East Sayan, Altay Sayan, Russia; *a*, holotype TPI collection 61r, specimen 8-100-34, longitudinal section,  $\times 28$  (Radugin, 1964); *b*, topotype TPI collection 5, locality 61r8, specimen 111, transverse section,  $\times 20$  (Jankauskas, 1969).

*Erphyllum* RADUGIN, 1966, p. 107 [\**E. bephylliforme*; OD; holotype, RADUGIN, 1966, pl. 7, 36, collection 61r, specimen 8-46-1, TPI, Tomsk] [= *Erphyllum* RADUGIN, 1964, p. 146, *nom. nud.*; = *Archaeobullatus* JANKAUSKAS, 1965, p. 440, *nom. nud.*, both invalid genus-group names based on unavailable type species]. Transverse section cardioid; peripterates well developed; inner wall contiguous. *lower Cambrian (Atd. 1)*: Altay Sayan.—FIG. 2, 7a–b. \**E. bephylliforme*, Ungut Formation, Atdabanian, Mana River, East Sayan, Altay Sayan, Russia; *a*,

topotype, TPI collection 61r, specimen 8, thin section 32, transverse section,  $\times 20$ ; *b*, topotype, TPI specimen 1, thin section 309, longitudinal section,  $\times 20$  (Jankauskas, 1969).

### Family STRIATOCYATHIDAE Vologdin & Jankauskas, 1968

[Striatocyathidae VOLOGDIN & JANKAUSKAS, 1968, p. 200] [=Achorocyathidae JANKAUSKAS, 1965, p. 440, *nom. nud.*, invalid family-group name based on unavailable genus name; =Achorocyathidae JANKAUSKAS, 1969, p. 151]

Peripterates open. *lower Cambrian (Atd. 1–Bot. 1)*.

*Striatocyathus* VOLOGDIN & JANKAUSKAS, 1968, p. 201 [\**S. murtukensis*; OD; holotype, VOLOGDIN & JANKAUSKAS, 1968, fig. 1(15), JANKAUSKAS, 1972, fig. 14(1), pl. 29, 2, thin section 2k-148, TPI,



Tomsk] [= *Gracilocyathus* VOLOGDIN & JANKAUSKAS, 1968, p. 201 (type, *G. condensus*, OD); = *Tortocyathus* VOLOGDIN & JANKAUSKAS, 1968, p. 201 (type, *T. ujarensis*, M); = *Iortocyathus* VOLOGDIN & JANKAUSKAS, 1968, p. 201, *nom. null.*, *lapsus calami pro Tortocyathus* VOLOGDIN & JANKAUSKAS, 1968, p. 201]. Transverse section circular to elliptical; peripterates well developed, open externally; inner wall of curved striae. *lower Cambrian (Atd.1–Bot.1)*: Siberian Platform, Altay Sayan, Tuva, Mongolia, Transbaikalia, Far East.—FIG. 3, 1a–b. \**S. murtukensis*, Siner Formation, Botoman, Murtuk Creek, Mana River, East Sayan, Altay Sayan, Russia; *a*, holotype, TPI thin section 2k-148, longitudinal section,  $\times 15$ ; *b*, paratype, TPI thin section 2k-60, transverse section,  $\times 15$  (Jankauskas, 1972).

**Achorocyathus** JANKAUSKAS, 1969, p. 152 [\**A. perbellus*; OD; holotype, JANKAUSKAS, 1965, fig. 1(20); JANKAUSKAS, 1969, fig. 26, collection 5, thin section 62-26-V, specimen 1, TPI, Tomsk] [= *Achorocyathus* JANKAUSKAS, 1965, p. 440, *nom. nud.*; = *Topolinocyathus* JANKAUSKAS, 1965, p. 440, *nom. nud.*, both invalid genus-group names based on unavailable type species; = *Topolinocyathus* JANKAUSKAS, 1969, p. 153 (type, *T. popovi*, OD), for discussion, see JANKAUSKAS (1973, p. 48)]. Transverse section circular to elliptical; peripterates well developed, open internally; inner wall of curved striae. *lower Cambrian (Atd.1–Atd.3)*: Altay Sayan, Mongolia.—FIG. 3, 2a–c. \**A. perbellus*, Krol Formation, Atdabanian, Mana River, East Sayan, Altay Sayan, Russia; *a*, holotype, TPI collection 5, thin section 62-26-V, specimen 1, sketch of longitudinal section,  $\times 20$ ; *b*, paratype, TPI collection 5, thin section 62-26, transverse section,  $\times 15$ ; *c*, paratype, TPI collection 5, thin section 62-26, longitudinal section,  $\times 15$  (Jankauskas, 1969).

**Rarocyathus** VOLOGDIN & JANKAUSKAS, 1968, p. 203 [\**R. tubulosus*; M; holotype, VOLOGDIN & JANKAUSKAS, 1968, fig. 1(7); JANKAUSKAS, 1972, fig. 19(1), collection JANKAUSKAS, 1965, thin section 141, specimen 1, TPI, Tomsk]. Transverse section circular to elliptical; peripterates well developed, open externally; inner wall of planar striae. *lower Cambrian (Atd.3–Bot.1)*: Altay Sayan, Transbaikalia, Far East.—FIG. 3, 3. \**R. tubulosus*, Bagrad Formation, Atdabanian, Kiya River, Kuznetsk Alatau, Russia, holotype, TPI collection Jankauskas, 1965, thin section 141, specimen 1, sketch of longitudinal section,  $\times 15$  (Vologdin & Jankauskas, 1968).

## Order CRIBRICYATHIDA Vologdin, 1961

[*nom. correct.* VOLOGDIN, 1964, p. 1392, *pro* Cribrocycathida VOLOGDIN, 1961, p. 177] [= Conoidocyathida VOLOGDIN, 1964, p. 1392]

Baculi present, imparting cancellate relief where well developed. *lower Cambrian (Atd.1–Bot.3)*.

## Superfamily CONOIDOCYATHOIDEA Vologdin, 1964

[*nom. transl. et correct.* ZHURAVLEV & KRUSE, herein, *ex* Conoidocyathidea VOLOGDIN, 1964, p. 1392]

Cup one-walled. *lower Cambrian (Atd.1–Bot.3)*.

## Family CONOIDOCYATHIDAE Vologdin, 1964

[*nom. correct.* ZHURAVLEV & KRUSE, herein, *pro* Conoidocyathidea VOLOGDIN, 1964, p. 1392]

Peripterates open. *lower Cambrian (Atd.1–Bot.3)*.

**Conoidocyathus** VOLOGDIN, 1964, p. 1392 [\**C. artus*; M; holotype, VOLOGDIN, 1964, fig. 1(2); VOLOGDIN, 1966, fig. 4, pl. 1, 5, 1924/26, PIN, Moscow] [= *Pubericycathus* VOLOGDIN, 1964, p. 1392, *nom. nud.*, invalid genus-group name based on unavailable type species; = *Azyrcycathus* VOLOGDIN, 1964, p. 1392 (type, *A. transeptatus*, OD); = *Pubericycathus* VOLOGDIN, 1966, p. 20 (type, *P. phialiformis*, OD); = *Azyrcycathus* VOLOGDIN, 1966, p. 23, *nom. null.*; = *Azyrcycathus* VOLOGDIN, 1966, p. 23, *nom. null.*]. Transverse section circular to elliptical; peripterates well developed, open externally; baculi weakly expressed. *lower Cambrian (Atd.1–Bot.3)*: Altay Sayan, Mongolia, Transbaikalia, Urals.—FIG. 3, 4. \**C. artus*, Usa Formation, Botoman, Sukhie Solontsy Valley, Batenev Range, Kuznetsk Alatau, Altay Sayan, Russia, longitudinal section,  $\times 10$  (Vologdin, 1966).

## Superfamily PYXIDOCYATHOIDEA Vologdin, 1964

[*nom. transl.* ZHURAVLEV & KRUSE, herein, *ex* Pyxidocyathidae VOLOGDIN, 1964, p. 1394]

Cup two-walled. *lower Cambrian (Atd.1–Bot.3)*.

## Family PYXIDOCYATHIDAE Vologdin, 1964

[Pyxidocyathidae VOLOGDIN, 1964, p. 1394] [= Cribricyathidae VOLOGDIN, 1964, p. 1392, *nom. nud.*, invalid family-group name based on unavailable genus name; = Capillicyathidae VOLOGDIN, 1964, p. 1394; = Szecyathidae VOLOGDIN in REPINA & others, 1964, p. 251; = Cribricyathidae VOLOGDIN, 1966, p. 25]

Peripterates open. *lower Cambrian (Atd.1–Bot.3)*.

**Szeczyathus** VOLOGDIN, 1957, p. 493 [\**S. cylindricus*; OD; syntype(s), VOLOGDIN, 1932, fig. 7g–e, VOLOGDIN, 1957, fig. 1v, holotype not designated,

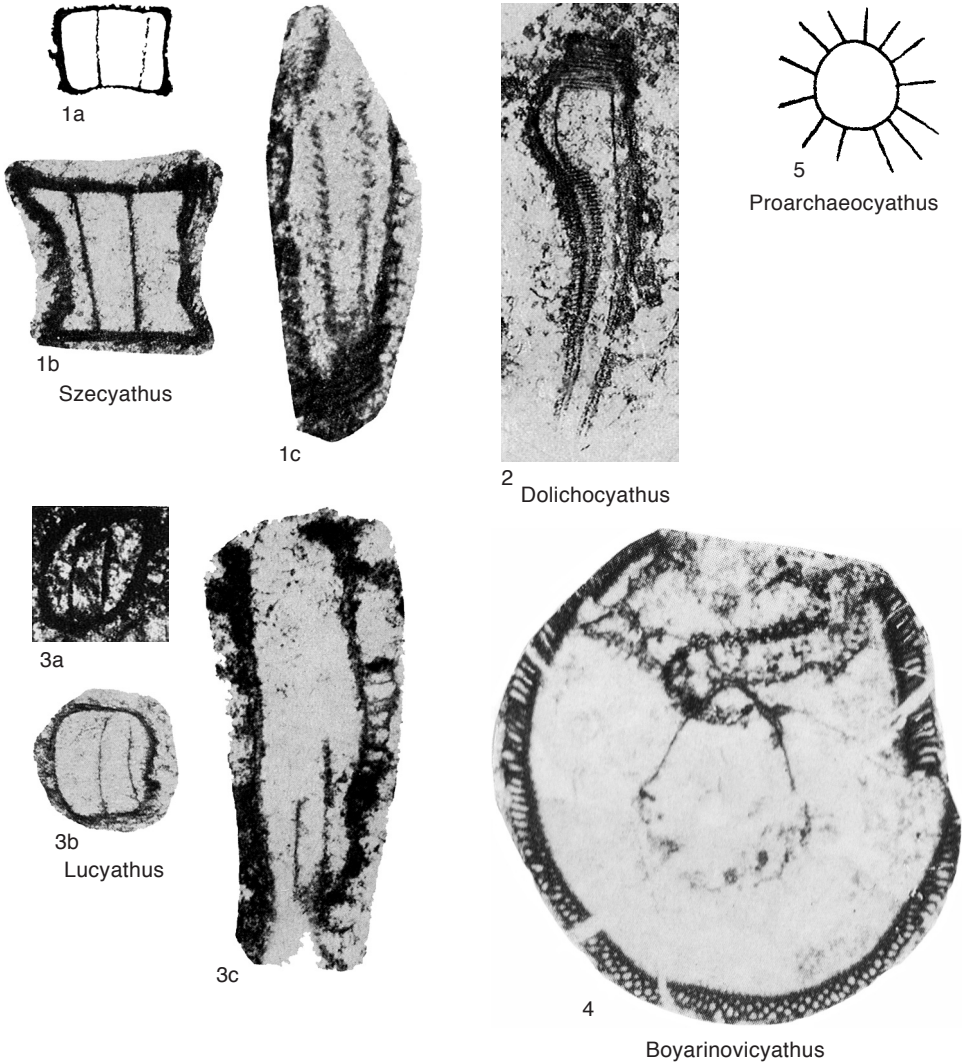


FIG. 4. Pyxidocyathidae, Boyarinovicyathidae, and Uncertain calcareous microfossils (p. 7–9).

collection not located] [= *Cribricyathus* VOLOGDIN, 1964, p. 1392, *nom. nud.*; = *Lomatiocyathus* VOLOGDIN, 1964, p. 1392, *nom. nud.*, both invalid genus-group names based on unavailable type species; = *Thecocyathus* VOLOGDIN, 1964, p. 1392 (type, *T. tetragonus*, OD); = *Pyxidocyathus* VOLOGDIN, 1964, p. 1394 (type, *P. gracilis*, OD); = *Radicicyathus* VOLOGDIN, 1964, p. 1394 (type, *R. canaliculatus*, OD); = *Radiacyathus* VOLOGDIN, 1964, p. 1394, *nom. null.*, *lapsus calami pro Radicicyathus* VOLOGDIN, 1964, p. 1394; = *Redicicyathus* VOLOGDIN, 1964, p. 1394, *nom. null.*, *lapsus calami pro Radicicyathus* VOLOGDIN, 1964, p. 1394; = *Cribricyathus* VOLOGDIN, 1966, p. 26 (type, *C. longus*, OD); = *Lomatiocyathus*

VOLOGDIN, 1966, p. 28 (type, *L. clathratus*, OD); = *Thecicyathus* VOLOGDIN, 1966, p. 31, *nom. null.*, *lapsus calami pro Thecocyathus* VOLOGDIN, 1964, p. 1392; = *Abicyathus* JANKAUSKAS, 1972, p. 172 (type, *Lomatiocyathus asymmetricus* VOLOGDIN, 1966, p. 29, OD)]. Transverse section quadrate; peripterates well developed, open externally; inner wall of planar striae. *lower Cambrian (Atd.2–Bot.3)*: Altay Sayan, Mongolia.—FIG. 4, 1a–c. \**S. cylindricus*, a, Verkhneynyrnga Formation, Botoman, Lebed' River, Altay Mountains, Altay Sayan, Russia, unlocated topotype, sketch of transverse section,  $\times 20$  (Vologdin, 1932); b, Mazas Formation, Botoman, Mrassu River, Gornaya Shoria, Altay Sayan, Russia,

unlocated specimen collection Zhuravleva, 1964, collection 440, specimen 33/41, thin section 2, transverse section,  $\times 20$ ; *c*, Verkhneomonok Formation, Botoman, Kazly River, West Sayan, Altay Sayan, Russia, TPI collection Jankauskas, 1966, specimen IIIa, thin section 19, longitudinal section,  $\times 25$  (Jankauskas, 1972).

**Dolichocyathus** VOLOGDIN, 1964, p. 1394 [*\*D. effiguratus*; OD; holotype, VOLOGDIN, 1964, fig. 1(15); VOLOGDIN, 1966, fig. 20, pl. 2, 12, M, 1924/741, PIN, Moscow] [= *Apocyathus* VOLOGDIN, 1964, p. 1394 (type, *A. ovalis*, OD); ? = *Capillicyathus* VOLOGDIN, 1964, p. 1394 (type, *C. fimbriatus*, OD); ? = *Lagenicyathus* VOLOGDIN, 1964, p. 1394 (type, *L. lamellifer*, OD)]. Transverse section circular to elliptical; peripterates well developed, open externally; inner wall of planar striae oriented normal to wall, linked by longitudinal lintels. *lower Cambrian* (Bot. 1–Bot. 3): Altay Sayan, Tuva, Transbaikalia. — FIG. 4, 2. *\*D. effiguratus*, Usa Formation, Botoman, Sukhie Solontsy Valley, Batenev Range, Kuznetsk Alatau, Russia, holotype, PIN 1924/741, longitudinal section,  $\times 10$  (Vologdin, 1966).

**Lucyathus** VOLOGDIN, 1957, p. 495 [*\*L. elegans*; OD; syntype(s), VOLOGDIN, 1932, fig. 7a,b,m; VOLOGDIN, 1957, fig. 1e,zh, 2a–v [left], holotype not designated, collection not located] [= *Longicyathus* VOLOGDIN, 1964, p. 1394 (type, *L. pubescens*, OD); = *Sunicyathus* VOLOGDIN, 1964, p. 1394 (type, *S. pulcher*, M); = *Turricyathus* VOLOGDIN, 1964, p. 1394 (type, *T. procerulus*, OD); = *Peripteratoocyathus* VOLOGDIN, 1964, p. 1394 (type, *P. cirratus*, OD), for discussion, see JANKAUSKAS (1972, p. 176)]. Transverse section quadrate; peripterates well developed, open externally; inner wall contiguous. *lower Cambrian* (Atd. 3–Bot. 3): Altay Sayan, Transbaikalia. — FIG. 4, 3a–c. *\*L. elegans*; *a*, Verkhneomonok Formation, Botoman, Sanashtykgol River, West Sayan, Altay Sayan, Russia, unlocated topotype, transverse section,  $\times 20$  (Vologdin, 1957); *b*, Adiak Formation, Atdabanian, Mrassu River, Gornaya Shoria, Altay Sayan, Russia, unlocated specimen collection Zhuravleva, 1961, collection 440, specimen 43/41, thin section 2, transverse section,  $\times 20$ ; *c*, Kacha Formation, Botoman, Kookta River, Transbaikalia, Russia, unlocated specimen collection 451, specimen 321/2, thin section 1, longitudinal section,  $\times 20$  (Jankauskas, 1972).

## Phylum UNCERTAIN

### CALCAREOUS MICROFOSSILS OF UNCERTAIN AFFINITY RESEMBLING CRIBRICYATHS

#### Family BOYARINOVICYATHIDAE Zhuravleva, 1997

[Boyarinovicyathidae ZHURAVLEVA in ZHURAVLEVA & others, 1997, p. 151]

**Boyarinovicyathus** ZHURAVLEVA in ZHURAVLEVA & others, 1997, p. 151 [*\*B. alexandri*; OD; holotype,

ZHURAVLEVA & others, 1997, pl. 8, 10, 2329/116, ZSGGU, Novokuznetsk]. Two-walled saclike cup of probable magnesium calcite composition; outer wall aporose with honeycomb-like pits that open externally; inner wall with simple pores. *lower Cambrian* (Bot. 3): Altay Sayan. — FIG. 4, 4. *\*B. alexandri*, Usa Formation, Botoman, Bol'shaya Belokamenka River, Kuznetsk Alatau, Russia, holotype ZSGGU 2329/116, oblique longitudinal section,  $\times 10$  (Zhuravleva & others, 1997).

## Family UNCERTAIN

**Proarchaeocyathus** RADUGIN, 1966, p. 112 [*\*P. manae*; OD; holotype, RADUGIN, 1964, pl. 1, 1; RADUGIN, 1966, pl. 7, 1, collection 61r, specimen 8-100, TPI, Tomsk] [= *Proarchaeocyathus* RADUGIN, 1964, p. 146, *nom. nud.*, invalid genus-group name based on unavailable type species]. Hollow possible tube of rounded possible cross section bearing spines or longitudinal ribs on external surface. *lower Cambrian* (Atd. 1): Altay Sayan. — FIG. 4, 5. *\*P. manae*, Ungut Formation, Atdabanian, Mana River, East Sayan, Altay Sayan, Russia, holotype, TPI collection 61r, specimen 8-100, transverse section,  $\times 7.5$  (Radugin, 1964).

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