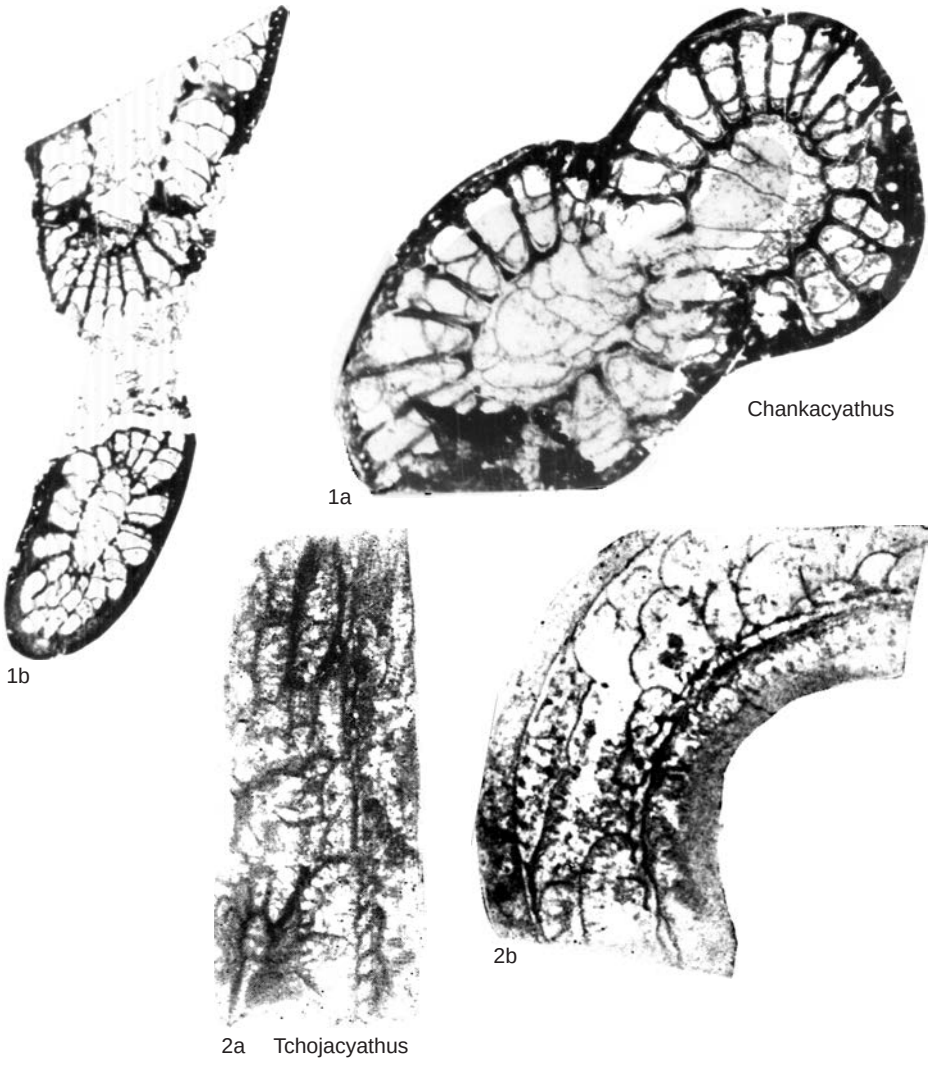


FIG. 618. Chankacyathidae and Tchojacyathidae (p. 1042–1043).

Tyrga River, Altay Mountains, Russia, holotype, PIN 4297/11; *a,* longitudinal section (outer wall to left), ×6; *b,* transverse section, ×6 (Rozanov, 1960b).

Suborder ANTHOMORPHINA Okulitch, 1935

[*nom. transl.* DEBRENNE, 1991, p. 219, *ex* Anthomorphida OKULITCH, 1955a, p. 18, *nom. correct. pro* order Anthomorphina OKULITCH, 1935b, p. 90] [=subclass Anthocyatha OKULITCH, 1943, p. 46; =Araneocyathida VOLOGDIN, 1961, p. 182]

Cup solitary or modular (pseudocolonies formed by external budding); intervallum with pseudosepta and membrane tabulae. *lower Cambrian (Bot.1).*

Superfamily ANTHOMORPHOIDEA Okulitch, 1935

[*nom. transl.* DEBRENNE & ZHURAVLEV, 1992b, p. 113, *ex* Anthomorphidae OKULITCH, 1935b, p. 97]

Outer wall simple, with pores of anthoid type; microporous membranes of similar

structure to tabulae may be present. *lower Cambrian (Bot.1).*

Family ANTHOMORPHIDAE Okulitch, 1935

[Anthomorphidae Okulitch, 1935b, p. 97] [=Anthomorphinae Okulitch, 1935b, *nom. transl.* Fonin, 1985, p. 121, *ex* Anthomorphidae Okulitch, 1935b, p. 97; =Araneocyathidae Vologdin, 1956, p. 878; =Serligocyathidae Vologdin, 1959a, p. 670; =Rudicyathinae Fonin in Zhuravlev, Zhuravleva, & Fonin, 1983, p. 26; =Vertocyathinae Fonin, 1985, p. 110]

Inner wall with simple pores. *lower Cambrian (Bot.1).*

Anthomorpha Bornemann, 1884, p. 705 [**A. margarita*; M; lectotype, Bornemann, 1886, pl. 28,*1a,4–6;* Debrenne, 1964, pl. 45,*1;* SD Debrenne, 1964, p. 233, GML 897a, Halle]. Inner wall with one row of simple pores per intersept; pseudosepta aporose even in early ontogenetic stages; membrane tabulae may be present. *lower Cambrian (Bot.1):* Tuva, ?Far East, Morocco, Iberia, France, Sardinia.——Fig. 619,*1a–b*. **A. margarita*, Matoppa Formation, Botoman; *a,* Cuccuru Contu, Sardinia, Italy, lectotype, GML 897a, transverse section, ×4 (Debrenne, Zhuravlev, & Kruse, 2002); *b,* Gonnesa, Sardinia, Italy, paralectotype, MNHN M84133, specimen C GON 3-7, longitudinal section, ×3 (Debrenne, 1964).

Tollicyathus Chernysheva, 1960, p. 77 [**T. ishensis*; OD; holotype, Chernysheva, 1960, pl. 4,*1*, ZSGGU 503/1, Novokuznetsk] [=*Nellicyathus* Fonin in Repina & others, 1964, p. 247 (type, *N. nelliae*, OD); =*Rudicyathus* Fonin in Zhuravlev, Zhuravleva, & Fonin, 1983, p. 26 (type, *R. tersus*, OD); =*Vertocyathus* Fonin, 1985, p. 110 (type, *V. reduncus*, OD), for discussion, see Debrenne & Zhuravlev, 1992b, p. 67]. Inner wall with one row of simple pores per intersept; pseudosepta with pores restricted to outer wall area, but coarsely porous in early ontogenetic stages; membrane tabulae may be present. *lower Cambrian (Bot.1):* Altay Sayan, Tuva, Mongolia.——Fig. 619,*2a–b*. **T. ishensis*, Verkhneynyrga Formation, Botoman, Bol'shaya Isha River, Altay Mountains, Altay Sayan, Russia, holotype, ZSGGU 503/1; *a,* longitudinal section, ×5; *b,* transverse section, ×5 (Chernysheva, 1960).

Family SHIVELIGOCYATHIDAE Fonin, 1983

[*nom. transl.* Debrenne & Zhuravlev, 1992b, p. 113, *ex* Shiveligocyathinae Fonin, 1983, p. 12]

Inner wall with canals. *lower Cambrian (Bot.1).*

Shiveligocyathus Missarzhevskiy, 1961, p. 19 [**S. vesiculoides*; OD; holotype, Missarzhevskiy, 1961, pl. 1,*1*, PIN 1914/75M/44, Moscow, not located] [=*Voznesenskicyathus* Rodionova in Zhuravleva & others, 1967, p. 99 (type, *V. florens*, OD), for discussion, see Debrenne & Zhuravlev, 1992b, p. 130]. Inner wall with several rows of horizontal to upwardly projecting, straight communicating canals per intersept; pseudosepta finely porous; membrane tabulae may be present. *lower Cambrian (Bot.1):* Altay Sayan, Tuva, Mongolia.——Fig. 620*a–b*. **S. vesiculoides*, Shangan Formation, Botoman, Shivelig-Khem River, East Tannu-Ola Range, Tuva, Russia, paratype, PIN 1914/75M/00; *a,* longitudinal section, ×2 (Debrenne, Zhuravlev, & Kruse, 2002); *b,* oblique transverse section, ×2 (Missarzhevskiy, 1961).

Suborder ARCHAEOCYATHINA Okulitch, 1935

[*nom. transl.* Zhuravleva, 1960b, p. 271, *ex* Archaeocyathida Zhuravleva, 1955a, p. 17, *nom. correct. pro* order Archaeocyathina Okulitch, 1935b, p. 90] [=Archaeosyconina Zhuravleva, 1955a, p. 12, *nom. transl.* Zhuravleva, 1960b, p. 303, *ex* order Archaeosyconida Zhuravleva, 1955a, p. 12, *nom. correct.* Debrenne, 1964, p. 117, *pro* Archaeosyconiina Zhuravleva, 1960b, p. 303; =Dictyocyathina Vologdin, 1956, p. 878, *nom. transl.* Fonin in Voronin & others, 1982, p. 83, *ex* Dictyocyathida Vologdin, 1956, p. 878; =Chouberticyathina Debrenne, 1970a, p. 25, *nom. transl.* Fonin in Voronin & others, 1982, p. 83, *ex* Chouberticyathida Debrenne, 1970a, p. 25]

Cup solitary or modular (latter by external budding and/or longitudinal subdivision; encrusting forms develop by addition of new central cavities); intervallum with taeniae, pseudosepta, or pseudotaenial or dictyonal network; segmented tabulae may be present. *lower Cambrian (Tom.2–Toy.3), middle Cambrian*.

Superfamily DICTYOCYATHOIDEA Taylor, 1910

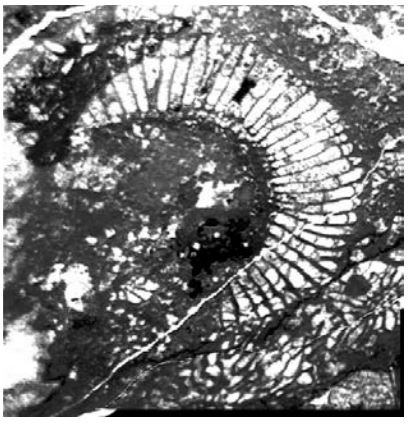
[*nom. transl.* Wood, Evans, & Zhuravlev, 1992, p. 492, *ex* Dictyocyathidae Taylor, 1910, p. 111]

Outer wall simple, either rudimentary (of marginal intervallar elements only) or basic (of marginal intervallar elements with additional linking lintels); segmented tabulae may be present. *lower Cambrian (Tom.2–Toy.1), middle Cambrian*.

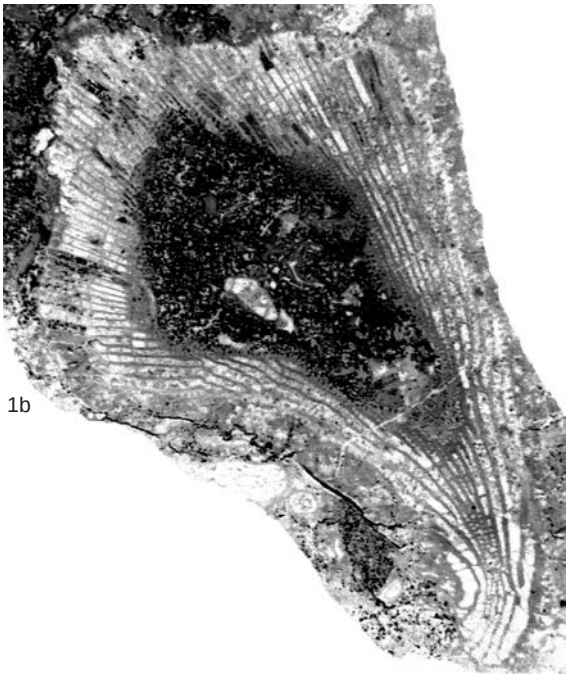
Family DICTYOCYATHIDAE Taylor, 1910

[Dictyocyathidae Taylor, 1910, p. 111] [=subfamily Dictyocyathinea Hernández-Sampelayo, 1933, p. 159; =Prismocyathidae Fonin, 1960, p. 725; =Paracoscinidae Debrenne, 1970a, p. 38, *nom. nud.*; =Paracoscinidae Debrenne, 1974a, p. 252; =Chouberticyathidae Debrenne, 1974a, p. 192; =Graphoscyphiidae Debrenne, 1974a, p. 204, *nom. correct.* Kruse, 1982, p. 196, *pro* Graphoscyphidae Debrenne, 1974a, p. 204]

Inner wall with simple pores. *lower Cambrian (Tom.2–Toy.1), middle Cambrian.*



1a Anthomorpha



1b

2a Tollicyathus

2b

FIG. 619. Anthomorphidae (p. 1044).

Dictyocyathus BORNEMANN, 1891a, p. 500 [**D. tenerrimus*; M; lectotype, BORNEMANN, 1891a, pl. 42,*5;* pl. 43,*4–6;* SD DEBRENNE, 1964, p. 200, not located; =*Coscinocyathus verticillus* BORNEMANN, 1886, p. 65; lectotype, BORNEMANN, 1886, pl. 15,*3g;* DEBRENNE, 1964, pl. 34,*5;* SD DEBRENNE, 1964, p. 205, GML 899c, Halle] [=*Prismocyathus* FONIN, 1960, p. 725 (type, *P. praesignis*, OD); =*Spongiosicyathus* ZHURAVLEVA in DATSENKO & others, 1968, p. 174 (type, *Dictyocyathus translucidus* ZHURAVLEVA, 1960b, p. 275, OD); =*Prismocyathellus* FONIN, 1990, p. 152 (type, *Prismocyathus verisimilis* FONIN, 1960, p. 726, OD; =*Prismocyathus praesignis* FONIN, 1960, p. 725)]. Outer wall basic; inner wall with one row of simple pores per intersept; dictyonal network. *lower Cambrian (Tom.2–Bot.1), middle Cambrian (Guzhangian):* Siberian Platform, Kolyma, Altay Sayan, Tuva, Mongolia, Far East, Kazakhstan, South China, Morocco, Iberia, Sardinia, Germany, *Tom.2–*

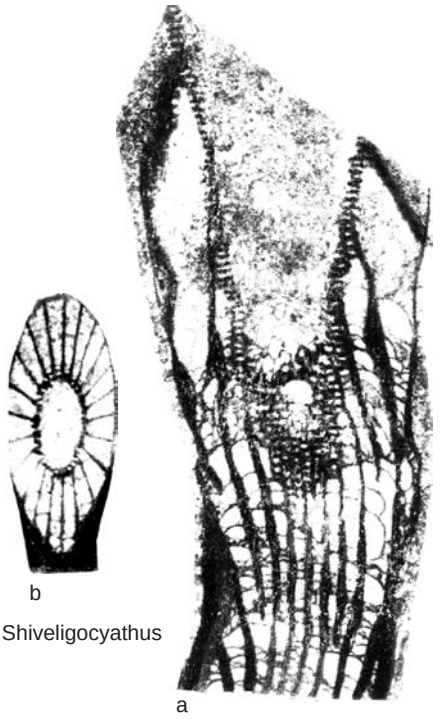


FIG. 620. Shiveligocyathidae (p. 1044).

Bot.1; Antarctica, *Guzhangian*.——FIG. 621,*1a–b*. **D. verticillus* (BORNEMANN), Matoppa Formation, Botoman, Cuccuru Contu, Sardinia, Italy; *a,* topotype, MNHN M84248, specimen CCC 9-1a, oblique longitudinal section, ×6 (Debrenne, Zhuravlev, & Kruse, 2002); *b,* lectotype, GML 899c, transverse section, ×6 (Debrenne, 1964).

Cellicyathus DEBRENNE & ZHURAVLEV, 1990, p. 300 [**Maturocyathus ornatus* FONIN, 1985, p. 118; OD; holotype, FONIN, 1985, pl. 22,*2,* PIN 1915/280, Moscow]. Outer wall basic, tabular; inner wall tabular, with one row of simple pores per intersept; taeniae coarsely porous; synapticulae and simply porous segmented tabulae may be present. *lower Cambrian (Bot.2–Toy.1):* Siberian Platform, Altay Sayan, Tuva.——FIG. 621,*2a–b*. **C. ornatus* (FONIN), Shangan Formation, Botoman, Ulug-Shangan River, East Tannu-Ola Range, Tuva, Russia; *a,* holotype, PIN 1915/280, transverse section, ×5; *b,* paratype, PIN 1915/300, longitudinal section (outer wall to right), ×3.5 (Fonin, 1985).

Chouberticyathus DEBRENNE, 1964, p. 208 [**C. clatratus*; OD; holotype, DEBRENNE, 1964, pl. 32,*1–3*, MNHN M80272, specimen Ki 140 P-6, Paris]. Outer wall imperforate (possibly rudimentary); inner wall with one row of simple pores per intersept; taeniae coarsely porous. *lower Cambrian (Bot.1):* Morocco, Iberia, Sardinia.——FIG. 621,*3a–b*. **C. clatratus*, Issafen Formation, Botoman, Tizi Oumeslema, Morocco, holotype, MNHN M80272, specimen Ki 140 P-6; *a,* transverse view, ×6; *b,* longitudinal view, ×6 (Debrenne & Zhuravlev, 1992b; ©Publications Scientifiques du Muséum national d'Histoire naturelle, Paris).

Graphoscyphia DEBRENNE in ZHURAVLEVA, 1974a, p. 164 [**Protopharetra graphica* R. BEDFORD & W. R. BEDFORD, 1934, p. 4; OD; lectotype, R. BEDFORD & W. R. BEDFORD, 1934, fig. 22; DEBRENNE, 1969a, pl. 12,*5;* SD DEBRENNE, 1969a, p. 346, NHM S4170, London]. Outer wall basic; inner wall with one row of simple pores per intersept; pseudosepta coarsely porous, linked by synapticulae. *lower Cambrian (Atd.4–Bot.3):* Altay Sayan, Australia, Antarctica, Mexico.——FIG. 621,*4a–b*. **G. graphica* (R. BEDFORD & W. R. BEDFORD), Ajax Limestone, Botoman, Ajax Mine, South Australia, Australia, lectotype, NHM S4170; *a,* internal longitudinal view of inner wall, ×6; *b,* transverse view, ×6 (Debrenne, Zhuravlev, & Kruse, 2002).

Molybdocyathus DEBRENNE & GANGLOFF in DEBRENNE, GANDIN, & GANGLOFF, 1990, p. 92 [**M. juvenilis*; OD; holotype, DEBRENNE, GANDIN, & GANGLOFF, 1990, pl. 2,*13*, USNM 443573, specimen IR 23.7a', Washington, D.C.]. Outer wall rudimentary; inner wall with one row of simple pores per intersept; dictyonal network. *lower Cambrian (Bot.1–Bot.2):* Altay Sayan, Tuva, Mongolia, United States.——FIG. 622,*1a–b*. **M. juvenilis*, Valmy Formation, Botoman, Iron Canyon, Nevada, United States; *a,* holotype, USNM 443573, specimen IR 23.7a', transverse and longitudinal sections of modular skeleton, ×8; *b,* paratype, USNM 443568, specimen IR 14.2, longitudinal section of modular skeleton, ×8 (Debrenne, Gandin, & Gangloff, 1990).

Paracoscinus R. BEDFORD & W. R. BEDFORD, 1936, p. 18 [**P. mirabile*; OD; holotype, R. BEDFORD & W. R. BEDFORD, 1936, fig. 85; DEBRENNE, 1974a, fig. 37a–b, SAM P988-169, -170, -171, Adelaide]. Outer wall basic, tabular; inner wall with one row of simple pores per intersept, each pore subdivided by median longitudinal rod; pseudosepta finely porous; segmented tabulae. *lower Cambrian (Bot.3–Toy.1):* Altay Sayan, Australia.——FIG. 622,*2a–d*. **P. mirabile*, Ajax Limestone, Botoman, Ajax Mine, South Australia, Australia; *a,* holotype, SAM P988-169, -170, -171, transverse view, ×6 (Debrenne & Zhuravlev, 1992b; ©Publications Scientifiques du Muséum national d'Histoire naturelle, Paris); *b,* paratype, USNM PU86680, specimen 241A, external view of outer wall, ×6 (Debrenne, Zhuravlev, & Kruse, 2002); *c–d,* holotype, SAM P988-169, -170, -171; *c,* longitudinal view, ×4; *d,* internal view of inner wall, ×7 (Debrenne, 1974a).

?Retilamina DEBRENNE & JAMES, 1981, p. 370 [**R. amourensis*; OD; holotype, DEBRENNE & JAMES, 1981, pl. 54,*4*, GSC 62128, specimen 169-5acT1, Ottawa]. Encrusting, domelike cup; upper wall (interpreted as outer) with pores regularly arranged but not at each intertaenia; pores commonly produced as chimneys; lower

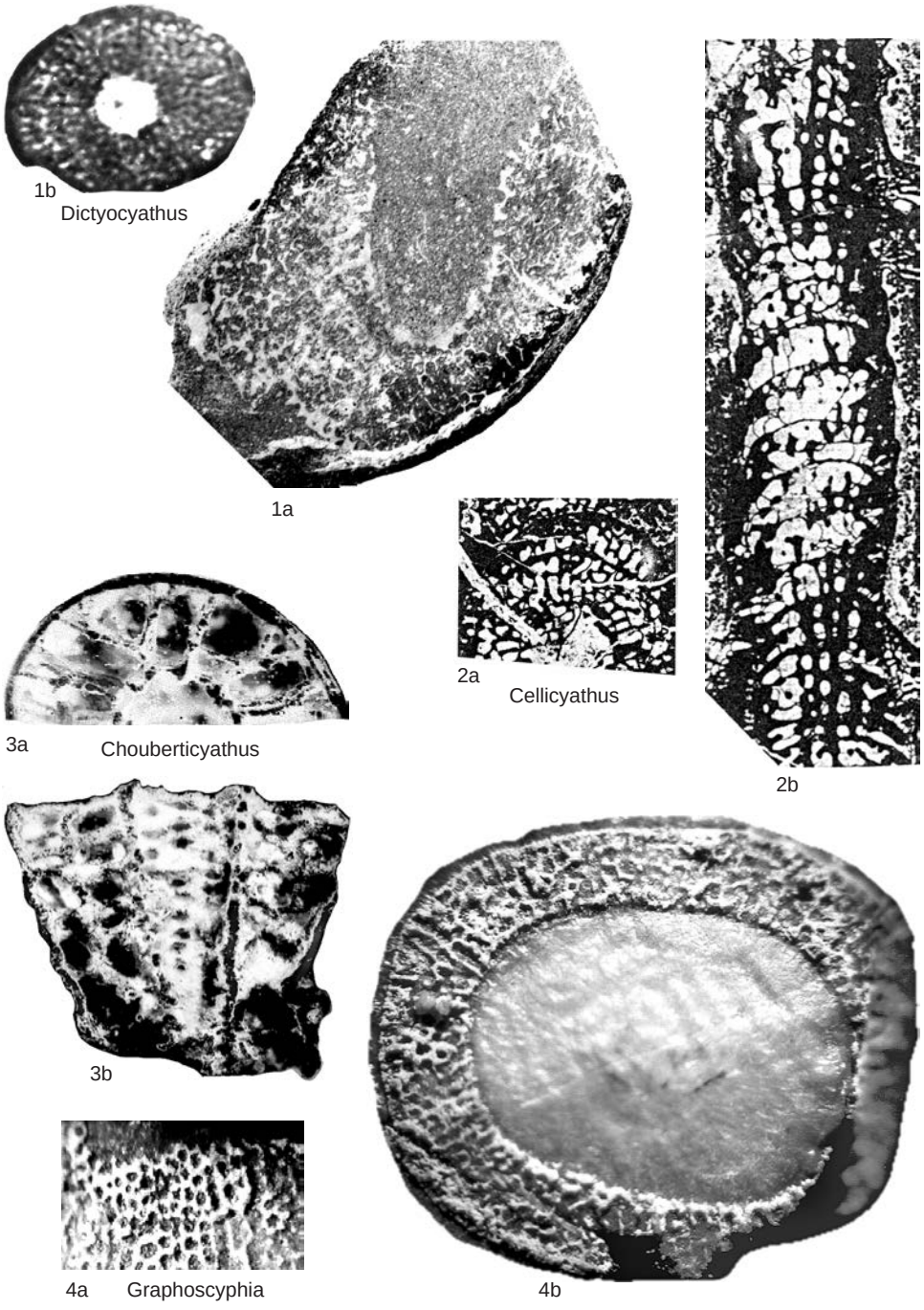
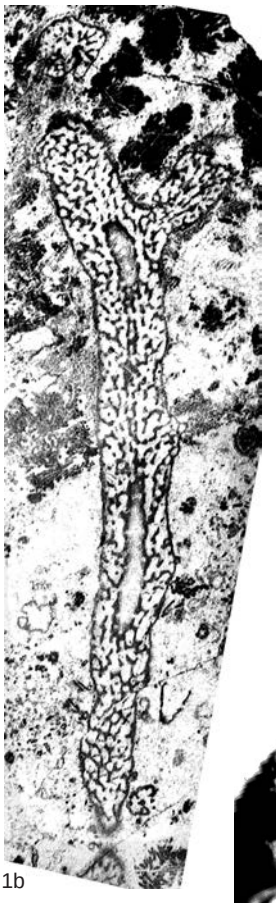


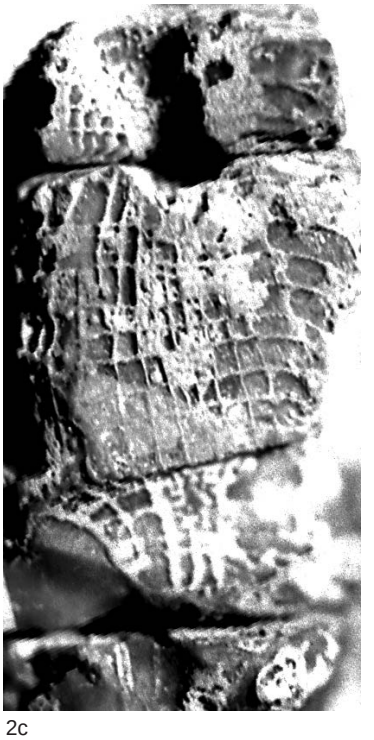
FIG. 621. Dictyocyathidae (p. 1045–1046).

1a Molybdocyathus



1b

2b



2c

2a

2d Paracoscinus

FIG. 622. Dictyocyathidae (p. 1046).

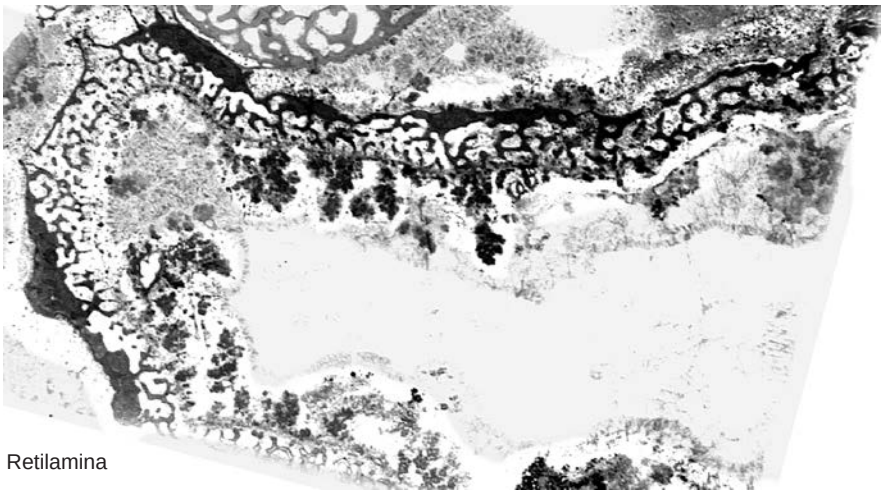


FIG. 623. Dictyocyathidae (p. 1046–1049).

(possibly inner) wall rudimentary; dictyonal or more probably pseudotaenial network. [Atypical cup shape does not provide certainty as to which wall is outer and which inner, and nature of intervallar elements and accepted inner wall remain doubtful.] *lower Cambrian (Bot.2–Bot.3):* Canada, United States, Mexico.——FIG. 623. **R. amourensis*, Forteau Formation, Botoman, Mount St. Margaret, Newfoundland, Canada, holotype, GSC 62128, specimen 169-5acT1, oblique section, ×6 (Debrenne, Zhuravlev, & Kruse, 2002).

Family CLARUSCOSCINIDAE Debrenne & Zhuravlev, 1992

[Claruscoscinidae DEBRENNE & ZHURAVLEV, 1992b, p. 114] [=Claruscoscinidae DEBRENNE in DEBRENNE, GANDIN, & ROWLAND, 1989, p. 167, *nom. nud.*]

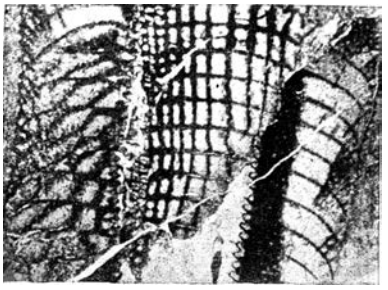
Inner wall with bracts, fused bracts, or pore tubes. *lower Cambrian (Bot.1–Toy.1).*

Claruscoscinus HANDFIELD, 1971, p. 74 [**Eucyathus billingsi* VOLOGDIN, 1940b, p. 48; OD; holotype not designated, collection not located] [=*Monstricyathus* VOLOGDIN, 1977, p. 60 (type, *M. tubiformis*, OD); =*Arisacyathus* KASHINA in OSADCHAYA & others, 1979, p. 166 (type, *A. diligens*, OD; =*Eucyathus billingsi* VOLOGDIN, 1940b, p. 48); =*Maturocyathus* FONIN, 1985, p. 114 (type, *M. makarovi*, OD; =*Eucyathus billingsi* VOLOGDIN, 1940b, p. 48); =*Costocyathus* FONIN, 1985, p. 119 (type, *C. mactus*, OD), for discussion, see DEBRENNE & ZHURAVLEV, 1992b, p. 123]. Outer wall basic, tabular; inner wall with one row of pores per intersept, bearing upwardly projecting, straight to S-shaped pore tubes; pseudosepta finely porous; segmented tabulae. *lower Cambrian (Bot.1–Toy.1):* Altay Sayan, Tuva, Mongolia, Transbaikalia, Far East, Canada, United States.——FIG. 624,*1a–c*. **C. billingsi* (VOLOGDIN), Verkhnemonok Formation, Botoman, Berezovaya River, Abakan River, West Sayan, Altay Sayan, Russia; *a,* unlocated syntype, longitudinal section, ×4 (Vologdin, 1940b); *b,* transverse section, syntype PIN 4754/6, ×5 (Debrenne, Zhuravlev, & Kruse, 2002); *c,* unlocated syntype, longitudinal section, ×4 (Vologdin, 1940b).

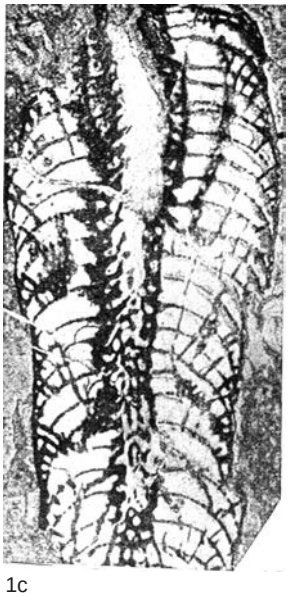
Fenestrocyathus HANDFIELD, 1971, p. 72 [**F. complexus*; OD; holotype, HANDFIELD, 1971, pl. 14,*5;* pl. 15,*1*, GSC 25388, Ottawa]. Outer wall basic; inner wall with one row of pores per intersept, bearing upwardly projecting, S-shaped bracts or fused bracts; dictyonal network. *lower Cambrian (Bot.1–Bot.2):* Altay Sayan, Mongolia, Canada, United States.——FIG. 624,*2*. **F. complexus*, Sekwi Formation, Botoman, Mackenzie Mountains, Northwest Territories, Canada, holotype, GSC 25388, transverse section of modular skeleton, ×5 (Debrenne, Zhuravlev, & Kruse, 2002).

Landercyathus DEBRENNE & GANGLOFF in DEBRENNE, GANDIN, & GANGLOFF, 1990, p. 91 [**L. lewandowskii*; OD; holotype, DEBRENNE, GANDIN, & GANGLOFF, 1990, pl. 1,*13*, USNM 443571, specimen IR 23a, Washington, D.C.]. Outer wall simple; inner wall with one row of horizontal to upwardly projecting, straight to waved canals per intersept; canals may penetrate intervallum forming astrorhizae; dictyonal network. *lower Cambrian (Bot.2):* United States.——FIG. 624,*3*. **L. lewandowskii*, Valmy Formation, Botoman, Iron Canyon, Nevada, United States, holotype, USNM 443571, specimen IR 23a, oblique longitudinal section, ×4 (Debrenne, Gandin, & Gangloff, 1990).

Stevocyathus DEBRENNE in DEBRENNE, GANDIN, & ROWLAND, 1989, p. 166 [**S. elictus*; OD; holotype, DEBRENNE, GANDIN, & ROWLAND, 1989, pl. 12,*1*, MNHN M83100, specimen CR2-8, Paris]. Outer wall basic; inner wall with one row of pores per



1a



1c

1b

Claruscoscinus

3

Landercyathus

4a

Stevocyathus

4b

2

Fenestrocyathus

FIG. 624. Claruscoscinidae (p. 1049–1051).

intersept, bearing upwardly projecting, S-shaped bracts or fused bracts; taeniae coarsely porous, linked by synapticulae; simple segmented tabulae may be present. *lower Cambrian (Bot.2):* United States, Mexico.——FIG. 624,*4a–b*. **S. elictus*, Puerto Blanco Formation, Botoman, Caborca, Sonora, Mexico; *a,* paratype, MNHN M83107, specimen CR2*1-8, transverse section, ×6 (Debrenne, Zhuravlev, & Kruse, 2002); *b,* holotype, MNHN M83100, specimen CR2-8, oblique longitudinal section, ×6 (Debrenne, Gandin, & Rowland, 1989).

Family PYCNOIDOCOSCINIDAE Debrenne, 1974

[Pycnoidocoscinidae DEBRENNE, 1974a, p. 256] [=Pycnoidocoscinidae DEBRENNE, 1970a, p. 40, *nom. nud.*]

Inner wall compound. *lower Cambrian (Bot.3).*

Pycnoidocoscinus R. BEDFORD & W. R. BEDFORD, 1936, p. 19 [**P. pycnoideum*; OD; lectotype, R. BEDFORD & W. R. BEDFORD, 1936, fig. 87; SD DEBRENNE, 1970a, p. 40, SAM P990-175, -176, -177, Adelaide]. Outer wall basic; inner wall compound consisting of wall carcass and additional microporous sheath formed by tabulae; pseudosepta finely porous; segmented tabulae. *lower Cambrian (Bot.3):* Australia, ?Canada.——FIG. 625*a–b*. **P. pycnoideum*, Ajax Limestone, Botoman, Ajax Mine, South Australia, Australia, lectotype, SAM P990-175, -176, -177; *a,* transverse view (outer wall at top), ×4; *b,* tangential view of inner wall, ×6 (Debrenne, Zhuravlev, & Kruse, 2002).

Superfamily ARCHAEOCYATHOIDEA Hinde, 1889

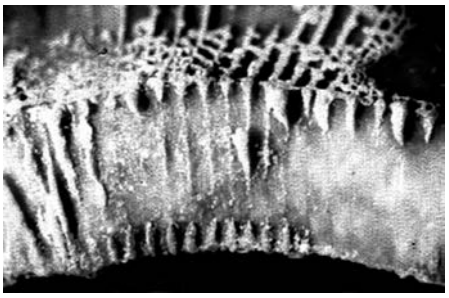
[*nom. correct*. ZHURAVLEV in VORONOVA & others, 1987, p. 32, *pro* Archaeocyathacea SIMON, 1939, p. 6, *nom. transl. ex* Archaeocyathidae TAYLOR, 1910, p. 105, *nom. correct*. *pro* family Archaeocyathinae HINDE, 1889, p. 141] [=Flindersicyathoidea R. BEDFORD & J. BEDFORD, 1939, p. 78, *nom. correct.* DEBRENNE & KRUSE, 1986, p. 268, *pro* Flindersicyathacea GRAVESTOCK, 1984, p. 115, *nom. transl. ex* Flindersicyathidae R. BEDFORD & J. BEDFORD, 1939, p. 78; =Vadimocyathacea KASHINA in OSADCHAYA & others, 1979, p. 160]

Outer wall concentrically porous. *lower Cambrian (Atd.1–Toy.3).*

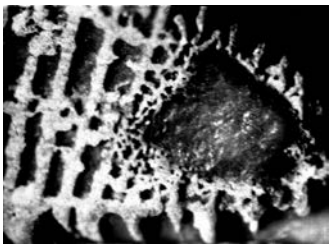
Family ARCHAEOPHARETRIDAE R. Bedford & W. R. Bedford, 1936

[Archaeopharetridae R. BEDFORD & W. R. BEDFORD, 1936, p. 17] [=Dictyocoscinidae R. BEDFORD & W. R. BEDFORD, 1936, p. 14, for discussion, see ZHURAVLEV & GRAVESTOCK, 1994, p. 34; =Protopharetridae VOLOGDIN, 1957a, p. 182; =Flindersicoscinidae DEBRENNE, 1974a, p. 246; =Salanycyathidae FONIN in VORONIN & others, 1982, p. 95; =Hawkercyathidae GRAVESTOCK, 1984, p. 115]

Inner wall with simple pores. *lower Cambrian (Atd.1–Bot.3).*



a

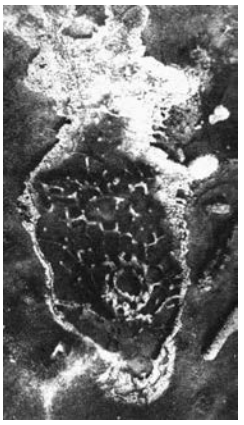


b

Pycnoidocoscinus

FIG. 625. Pycnoidocoscinidae (p. 1051).

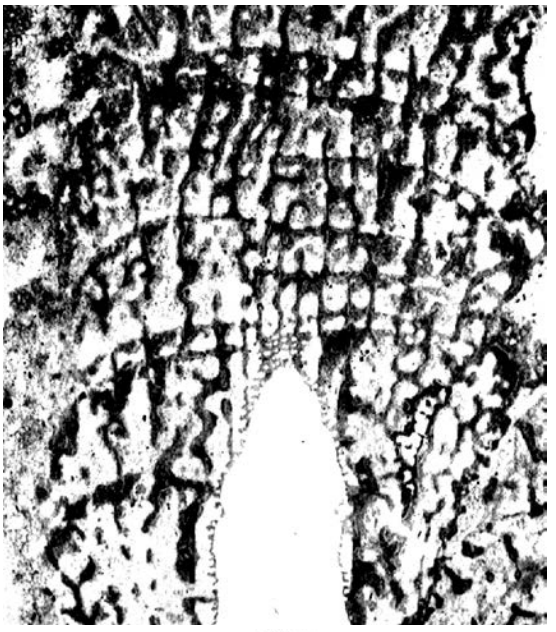
Archaeopharetra R. BEDFORD & W. R. BEDFORD, 1936, p. 17 [**A. typica*; OD; holotype, R. BEDFORD & W. R. BEDFORD, 1936, fig. 75; ZHURAVLEVA, 1963b, fig. 67a; DEBRENNE, 1974a, fig. 3b; SD HILL, 1965, p. 115, SAM P969, Adelaide; =*Dictyocyathus irregularis* TAYLOR, 1910, p. 145; lectotype, TAYLOR, 1910, pl. 12, photo 66; SD DEBRENNE, ZHURAVLEV, & KRUSE, 2002, p. 1665, SAM T1590, Adelaide] [=*Dictyocoscinus* R. BEDFORD & W. R. BEDFORD, 1936, p. 14 (type, *D. beltana*, OD; =*Dictyocyathus irregularis* TAYLOR, 1910, p. 145, for discussion, see ZHURAVLEV & GRAVESTOCK, 1994, p. 34); =*Tubocyathus* VOLOGDIN, 1937b, p. 473 (type, *T. smolianinovae*, M); =*Tubicyathus* VOLOGDIN, 1940a, p. 114, *nom. null.*; =*Tubulocyathus* VOLOGDIN, 1956, p. 880, *nom. null.*; =*Flindersicoscinus* DEBRENNE, 1970a, p. 34 (type, *Flindersicyathus tabulatus* R. BEDFORD & J. BEDFORD, 1937, p. 29, OD); =*Salanycyathus* FONIN in VORONIN & others, 1982, p. 95 (type, *S. marginatus*, OD); =*Hawkercyathus* GRAVESTOCK, 1984, p. 115 (type, *H. insculptus*, OD), for discussion, see DEBRENNE & ZHURAVLEV, 1992b, p. 120]. Inner wall with one row of simple pores per intersept; pseudotaeniae coarsely porous; concentrically porous segmented tabulae may be present. *lower Cambrian (Atd.1–Bot.3):* Altay Sayan, Tuva, Mongolia, Far East, Australia, Antarctica, South Africa (allochthonous), ?South China, ?Iberia.——FIG. 626,*1a–b*. **A. irregularis* (TAYLOR), Ajax Limestone, Botoman, Ajax Mine, South Australia, Australia; *a,* lectotype, SAM T1590, oblique longitudinal view,



1a

1b

Archaeopharetra



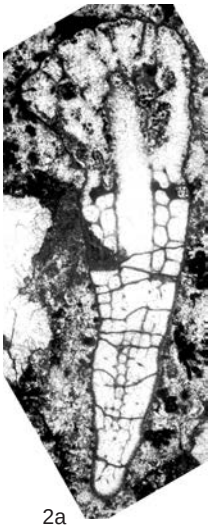
2a

2b

Markocyathus

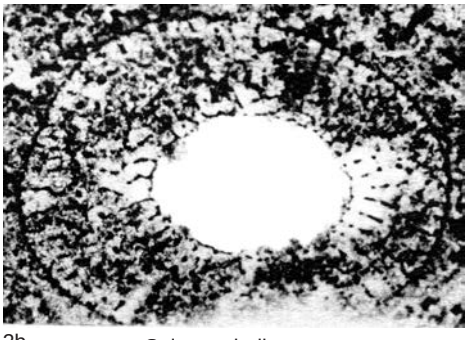
FIG. 626. Archaeopharetridae (p. 1051–1055).

1 Dictyosycon



2a

2c



2b Spirocyathella

FIG. 627. Archaeopharetridae (p. 1054–1055).

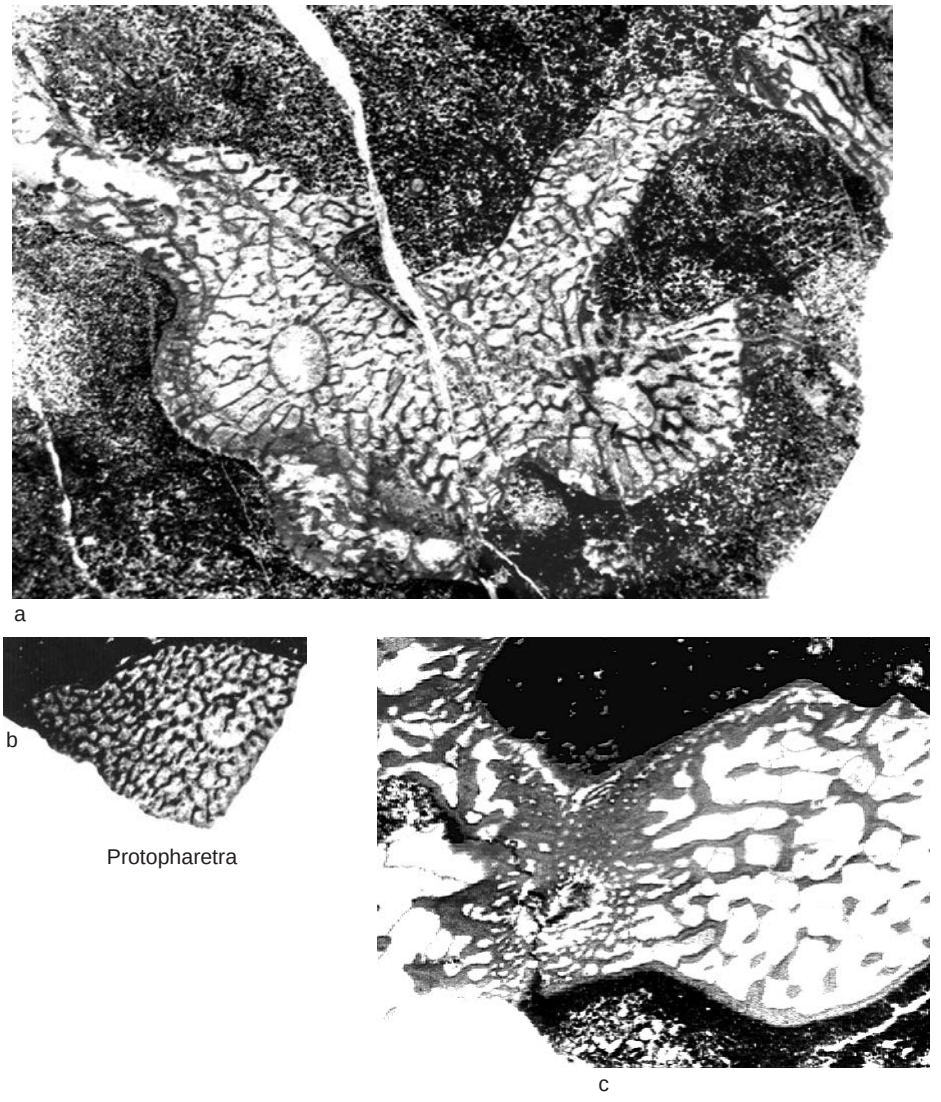


FIG. 628. Archaeopharetridae (p. 1055).

×5 (Debrenne, Zhuravlev, & Kruse, 2002); *b,* holotype [=*A. typica* R. BEDFORD & W. R. BEDFORD], SAM P969, longitudinal view, ×8 (Debrenne, 1974a).

Dictyosycon ZHURAVLEVA, 1960b, p. 307, *nom. transl.* DEBRENNE & ZHURAVLEV, 1992b, p. 124, *ex Sphinctocyathus (Dictyosycon)* ZHURAVLEVA, 1960b, p. 307 [**Sphinctocyathus (Dictyosycon) gravis*; OD; holotype, ZHURAVLEVA, 1960b, pl. 31,*7*, TsSGM 205/169, Novosibirsk]. Inner wall with one row of simple pores per intersept; dictyonal network; simple or concentrically porous segmented tabulae may be present. *lower Cambrian (Atd.1–Atd.4):* Siberian Platform, Altay Sayan, Tuva, Iberia.——FIG. 627,1. **D. gravis*, Pestrotsvet Formation, Atdabanian, Oy-Muran, Lena River, Sakha (Yakutia), Russia, holotype, TsSGM 205/169, oblique longitudinal section, ×4 (Zhuravleva, 1960b).

Markocyathus DEBRENNE in DEBRENNE, GANDIN, & ROWLAND, 1989, p. 165 [**M. clementensis*; OD; holotype, DEBRENNE, GANDIN, & ROWLAND, 1989, pl. 11,*1–2*, MNHN M83096, specimen CL-1e, Paris]. Inner wall with several rows of

simple pores per intersept; taeniae coarsely porous; concentrically porous segmented tabulae. *lower Cambrian (Bot.2):* Canada, Mexico.——FIG. 626,*2a–b*. **M. clementensis*, Puerto Blanco Formation, Botoman, Caborca, Sonora, Mexico, holotype, MNHN M83096, specimen CL-1e; *a,* detail of inner wall in tangential section, ×12 (Debrenne, Zhuravlev, & Kruse, 2002); *b,* transverse and longitudinal sections of modular skeleton, ×3 (Debrenne, Gandin, & Rowland, 1989).

Protopharetra BORNEMANN, 1884, p. 705 (BORNEMANN, 1883, p. 274, *nom. nud.*) [**P. polymorpha* BORNEMANN, 1886, p. 46; SD SIMON, 1939, p. 34; lectotype, BORNEMANN, 1886, pl. 5, fig. 4 bottom; SD SIMON, 1939, p. 35, not located; topotypes, MNHN M84120, specimens CGR3/3, GLA3.3, GLC10.II.1b, Paris] [=*Volvacyathus* DEBRENNE, 1960, p. 118 (type, *V. proteus*, OD), for discussion, see DEBRENNE & ZHURAVLEV, 1992b, p. 128]. Inner wall with one row of simple pores per intersept; taeniae coarsely porous, linked by rare synapticulae. *lower Cambrian (Atd.1–Bot.3):* Altay Sayan, Tuva, Far East, Tajikistan, Canada, United States, Morocco, Iberia, France, Sardinia, Germany.——FIG. 628*a–c*. **P. polymorpha*, Matoppa Formation, Botoman, Canal Grande, Sardinia, Italy; *a,* topotype, MNHN M84120, transverse section of modular skeleton, ×3 (Debrenne, Zhuravlev, & Kruse, 2002); *b,* lectotype, transverse section, ×3 (Bornemann, 1886); *c,* topotype, MNHN M84120, detail of outer wall in tangential section, ×7 (Debrenne, Zhuravlev, & Kruse, 2002).

Spirocyathella VOLOGDIN, 1939, p. 227 [**S. kyzlartauensis*; OD; holotype not designated, collection not located] [=*Aruntacyathus* KRUSE in WALTER, 1980, chart, *nom. nud.*; =*Amadedcyathus* KRUSE in WALTER, 1980, chart, *nom. nud.*; =*Aruntacyathus* KRUSE in KRUSE & WEST, 1980, p. 172 (type, *A. toddi*, OD); =*Spirocyathellus* FONIN in VORONIN & others, 1982, p. 98, *lapsus calami pro Spirocyathella* VOLOGDIN, 1939, p. 227, for discussion, see DEBRENNE & ZHURAVLEV, 1992b, p. 131]. Inner wall with several rows of simple pores per intersept; pseudotaenial network coarsely porous; concentrically porous segmented tabulae. *lower Cambrian (Atd.4–Bot.2):* Altay Sayan, Urals, Canada, United States, Mexico, Australia, Antarctica, Falkland Islands (allochthonous), South Africa (allochthonous), France.——FIG. 627,*2a–c*. **S. kyzlartauensis*, Terekla Formation, Botoman, Mt. Kizlar-Tau, western flank of southern Urals, Russia; *a,* topotype, PIN 4451/26, longitudinal section, ×8 (Debrenne & Zhuravlev, 1992b; ©Publications Scientifiques du Muséum national d'Histoire naturelle, Paris); *b–c,* unlocated syntype, 4-M, thin section 4; *b,* transverse section, ×6; *c,* longitudinal section, ×6 (Vologdin, 1939).

Family ARCHAEOCYATHIDAE Hinde, 1889

[*nom. correct*. TAYLOR, 1910, p. 105, *pro* family Archaeocyathinae HINDE, 1889, p. 141] [=Spirocyathidae TAYLOR, 1910, p. 112; =Archaeocyathinae HERNÁNDEZ-SAMPELAYO, 1933, p. 158, *nom. correct*. FONIN, 1985, p. 69, *pro* Archaeocyathinea HERNÁNDEZ-SAMPELAYO, 1933, p. 158; =Sigmofungiidae R. BEDFORD & W. R. BEDFORD, 1936, p. 16, *nom. correct*. DEBRENNE, 1970a, p. 42, *pro* Sigmofungidae R. BEDFORD & W. R. BEDFORD, 1936, p. 16; =Flindersicyathidae R. BEDFORD & J. BEDFORD, 1939, p. 78; =Flindersicyathinae R. BEDFORD & J. BEDFORD, 1939, p. 78, *nom. transl.* FONIN, 1985, p. 93, *ex* Flindersicyathidae R. BEDFORD & J. BEDFORD, 1939, p. 78; =Pycnoidocyathidae OKULITCH, 1950b, p. 394; ?=Protocyclocyathidae VOLOGDIN, 1956, p. 878; ?=Protocyclocyathellidae VOLOGDIN, 1956, p. 878, *lapsus calami* DEBRENNE & JAMES, 1981, p. 366, *pro* Protocyclocyathidae VOLOGDIN, 1956, p. 878; =Syringsellidae KRASNOPEEVA, 1961, p. 248; =Archaeofungiidae VOLOGDIN, 1962c, p. 90, *nom. correct*. HILL, 1965, p. 58, *pro* Archaeofungidae VOLOGDIN, 1962c, p. 90; =Vadimocyathidae KASHINA in OSADCHAYA & others, 1979, p. 161; =Claruscyathinae FONIN in ZHURAVLEVA & FONIN, 1983, p. 49]

Inner wall with bracts, fused bracts, or pore tubes. *lower Cambrian (?Atd.4, Bot.2–Toy.3).*

Archaeocyathus BILLINGS, 1861, p. 3 [**A. atlanticus* BILLINGS, 1861, p. 5; SD WALCOTT, 1886, p. 75; holotype, BILLINGS, 1861, fig. 5; HINDE, 1889, pl. 5,*8–10;* OKULITCH, 1943, pl. 5,*1–2*, GSC 369, Ottawa] [Original spelling was *Archeocyathus* BILLINGS; subsequent authors have used the diphthong] [=*Spirocyathus* HINDE, 1889, p. 136 (type, *Archeocyathus atlanticus* BILLINGS, 1861, p. 5, M); =*Retecyathus* VOLOGDIN, 1932, p. 20, *nom. nud.*; =*Claruscyathus* VOLOGDIN, 1932, p. 25 (type, *C. cumfundus*, M); =*Eucyathus* VOLOGDIN, 1937b, p. 466, *nom. nud.*; =*Flindersicyathus* R. BEDFORD & J. BEDFORD, 1937, p. 28, *nom. nud.*; =*Flindersicyathus* R. BEDFORD & J. BEDFORD, 1939, p. 78 (type, *F. decipiens*, OD); =*Eucyathus* VOLOGDIN in SIMON, 1939, p. 29 (type, *Claruscyathus cumfundus* VOLOGDIN, 1932, p. 25, OD); =*Retecyathus* VOLOGDIN in SIMON, 1939, p. 36 (type, *R. laqueus* VOLOGDIN, 1932, p. 20, SD SIMON, 1939, p. 36, =*Claruscyathus cumfundus* VOLOGDIN, 1932, p. 25); =*Syringsella* KRASNOPEEVA, 1961, p. 248 (type, *S. ynyrgensis*, OD); =*Batenevia* KRASNOPEEVA, 1961, p. 249 (type, *B. pellisi*, OD); =*Sanxiacyathus* YUAN & ZHANG, 1977, p. 8 (type, *S. hubeiensis*, OD); =*Bijacyathus* KRASNOPEEVA, 1978, p. 81 (type, *Archaeocyathus regularis* KRASNOPEEVA in ZHURAVLEVA, KRASNOPEEVA, & CHERNYSHEVA, 1960, p. 135, M, =*Retecyathus kusmini* VOLOGDIN, 1932, p. 21); =*Retecyathus (Pararetecyathus)* YUAN & ZHANG, 1978, p. 139 (type, *R. (P.) curvatus,* OD); =*Vadimocyathus* KASHINA in OSADCHAYA & others, 1979, p. 161 (type, *V. chikinevae*, OD), for discussion, see DEBRENNE & ZHURAVLEV, 1992b, p. 120]. Inner wall with one row of pores per intersept, bearing upwardly projecting, straight pore tubes; pseudotaenial network coarsely porous; concentrically porous segmented tabulae. *lower Cambrian (?Atd.4, Bot.2–Toy.3):* Siberian Platform, Altay Sayan, Tuva, Mongolia, Transbaikalia, Far East, Uzbekistan, Canada, United States, Mexico, Australia, Antarctica, South China, North China,

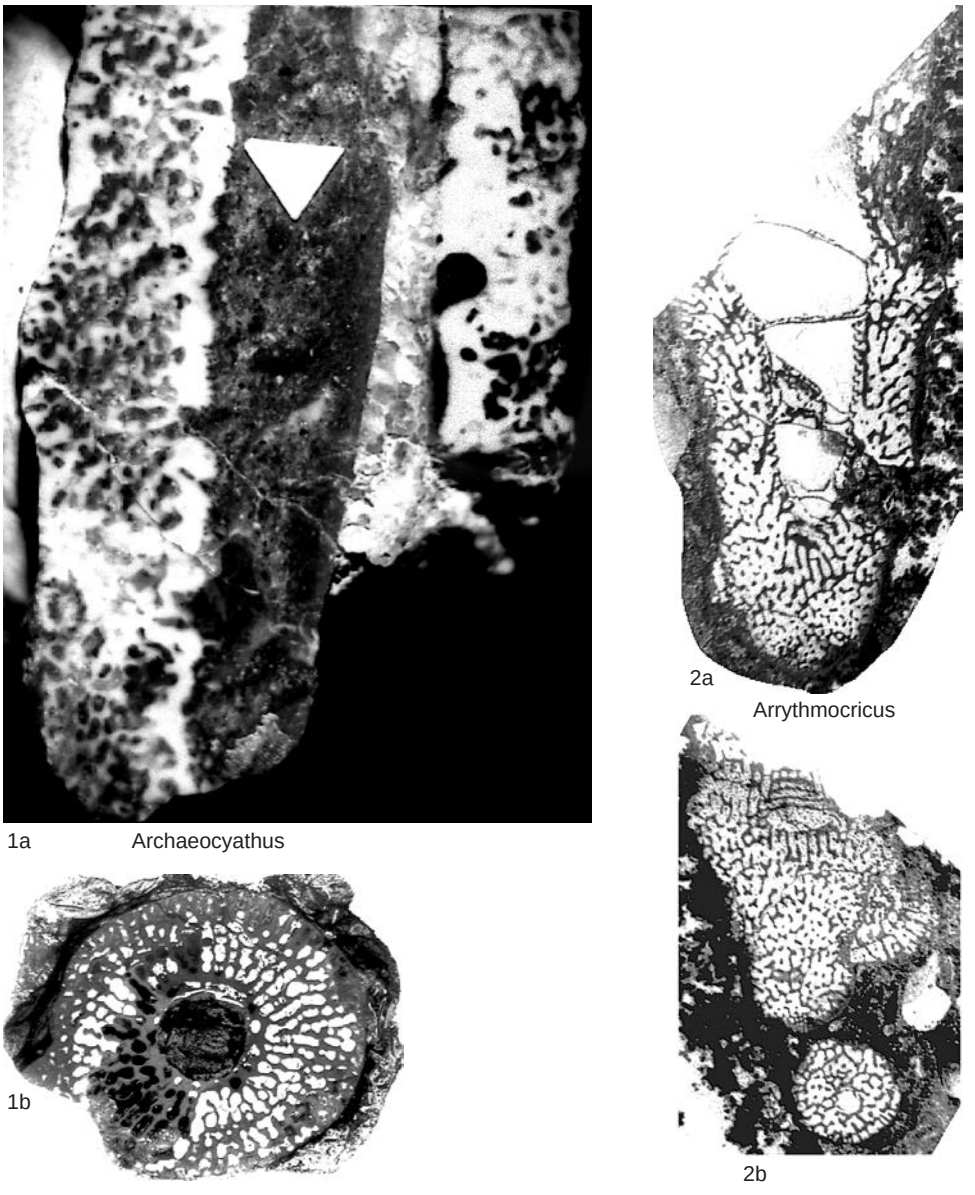
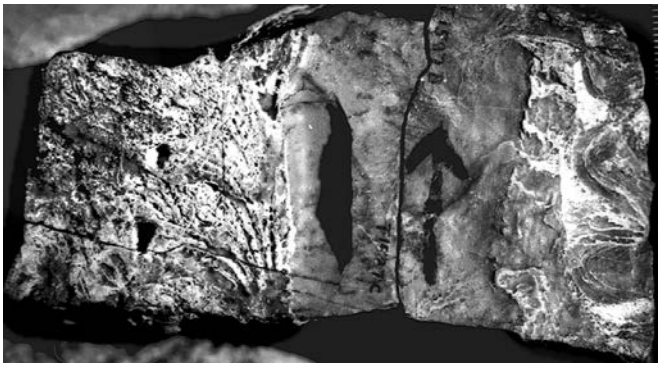


FIG. 629. Archaeocyathidae (p. 1055–1057).

Iberia, Sardinia.——FIG. 629,*1a–b*. **A. atlanticus*, Forteau Formation, Botoman, Anse au Loup, Labrador, Canada, holotype, GSC 369; *a,* longitudinal section (white triangle is adherent paper label), ×2.5 (Okulitch, 1943); *b,* transverse section, ×3 (Debrenne, Zhuravlev, & Kruse, 2002).

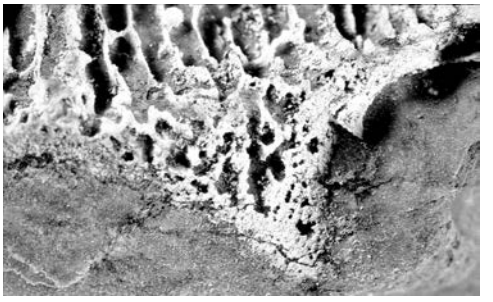
Arrythmocricus DEBRENNE & JAMES, 1981, p. 366 [**A. kobluki*; OD; holotype, DEBRENNE & JAMES, 1981, pl. 53,*3–4*, GSC 62123, Ottawa]. Inner wall with one row of pores per intersept, bearing upwardly projecting, S-shaped bracts or fused bracts; pseudotaenial network coarsely porous. *lower Cambrian*

a



b

Pycnoidocyathus



c

FIG. 630. Archaeocyathidae (p. 1057–1058).

(Bot.1–Bot.3): Canada, United States, Mexico.—— FIG. 629,*2a–b*. **A. kobluki*, Forteau Formation, Botoman, Fox Cove, Labrador, Canada, holotype, GSC 62123; *a,* longitudinal section of modular skeleton, ×5; *b,* longitudinal section (inner wall at top), ×5 (Debrenne & James, 1981).

Pycnoidocyathus TAYLOR, 1910, p. 131 [**P. synapticulosus*; SD R. BEDFORD & J. BEDFORD, 1939,

p. 78; lectotype, Taylor, 1910, pl. 12, photo 69; Debrenne, 1974a, fig. 13a–b; SD Debrenne, 1970a, p. 40, SAM T1587A,B,C, Adelaide] [=*Archaeofungia* Taylor, 1910, p. 131 (type, *A. ajax*, M); =*Batenevicyathus* Yaroshevich, 1962, p. 117, 122 (type, *B. zhuravlevae*, OD), for discussion, see Debrenne & Zhuravlev, 1992b, p. 129]. Inner wall with one row of pores per intersept, bearing upwardly projecting, straight pore tubes; taeniae coarsely porous, linked at base by synapticulae; during ontogeny, taeniae become progressively less porous, more planar and without synapticulae. *lower Cambrian (Bot.2–Toy.3):* Altay Sayan, Tuva, Mongolia, Far East, Australia, Antarctica, Falkland Islands (allochthonous), South China, North China, Iberia, Sardinia, Greenland, Canada, United States, Mexico.——Fig. 630*a–c*. **P. synapticulosus*, Ajax Limestone, Botoman, Ajax Mine, South Australia, Australia, lectotype, SAM T1587A–C; *a,* transverse view, ×1; *b,* longitudinal view, ×1; *c,* detail of outer wall in tangential view, ×4 (Debrenne, Zhuravlev, & Kruse, 2002).

Sigmofungia R. Bedford & W. R. Bedford, 1936, p. 16 [**S. flindersi*; M; lectotype, R. Bedford & W. R. Bedford, 1936, fig. 82; Hill, 1965, pl. 6,*1–2;* Debrenne, 1974a, fig. 30a–b; SD Hill, 1965, p. 89, SAM P963-115, -116, Adelaide] [=*Palmericyathellus* Debrenne, 1970a, p. 37 (type, *Sigmofungia tabularis* R. Bedford & J. Bedford, 1937, p. 29, OD, =*Sigmofungia flindersi* R. Bedford & W. R. Bedford, 1936, p. 16), for discussion, see Debrenne & Zhuravlev, 1992b, p. 130; =*Palmericyathus* Debrenne in Zhuravleva, 1974b, p. 15 (type, *Ethmophyllum lineatus* Greggs, 1959, p. 66, OD), *nom. null.*, *non* Handfield, 1971, p. 44, archaeocyath]. Inner wall with one row of pores per intersept, bearing upwardly projecting, S-shaped pore tubes; taeniae finely porous, linked by synapticulae; concentrically porous, segmented tabulae. *lower Cambrian (Bot.2–Bot.3):* Australia, Antarctica, Mexico.——Fig. 631*a–c*. **S. flindersi*, Ajax Limestone, Botoman, Ajax Mine, South Australia, Australia, lectotype, SAM P963-115, -116; *a,* transverse and longitudinal views, ×3 (Hill, 1965); *b,* detail of inner wall in oblique view, ×11 (Debrenne, 1974a); *c,* detail of outer wall in tangential view, ×10 (Debrenne, Zhuravlev, & Kruse, 2002).

Family ARCHAEOSYCONIDAE Zhuravleva, 1954

[Archaeosyconidae Zhuravleva, 1954, p. 30]

Inner wall compound. *lower Cambrian (Bot.1–Bot.3).*

Archaeosycon Taylor, 1910, p. 111 [**Archaeocyathus billingsi* Walcott, 1886, p. 74; M; holotype, Walcott, 1886, pl. 3,*3a–c;* Okulitch, 1943, pl. 14,*2–3*, USNM 15302, Washington, D.C.] [=*Pustulacyathellus* Debrenne & Gangloff in Voronova & others, 1987, p. 42 (type, *P. copulatus*, OD), for discussion, see Debrenne & Zhuravlev, 1992b, p. 121]. Outer wall tabular; inner wall compound, comprising wall carcass and tabulae; taeniae coarsely porous; concentrically porous segmented tabulae. *lower Cambrian (Bot.1–Bot.3):* Canada, United States.——Fig. 632*a–b*. **A. billingsi* (Walcott), Forteau Formation, Botoman, Anse au Loup, Labrador, Canada, holotype, USNM 15302; *a,* longitudinal section, ×3; *b,* transverse section, ×3 (Okulitch, 1943).

Superfamily METACYATHOIDEA R. Bedford & W. R. Bedford, 1934

[*nom. correct.* Debrenne & Kruse, 1986, p. 266, *pro* Metacyathacea Fonin, 1983, p. 11, *nom. transl. ex* Metacyathidae R. Bedford & W. R. Bedford, 1934, p. 5] [=Spirillicyathacea Gravestock, 1984, p. 111]

Outer wall compound. *lower Cambrian (Tom.2–Bot.3).*

Family COPLEICYATHIDAE R. Bedford & J. Bedford, 1937

[Copleicyathidae R. Bedford & J. Bedford, 1937, p. 29] [=Tabulacyathellidae Fonin in Voronin & others, 1982, p. 86; =Spirillicyathidae Gravestock, 1984, p. 111].

Inner wall with simple pores. *lower Cambrian (Tom.2–Bot.3).*

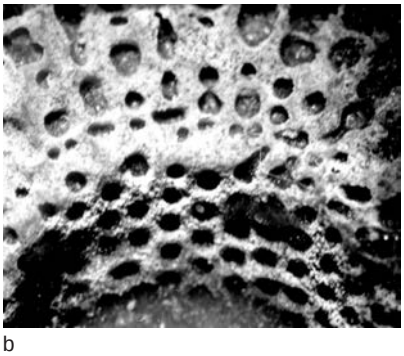
Copleicyathus R. Bedford & J. Bedford, 1937, p. 29 [**C. confertus*; OD; holotype, R. Bedford & J. Bedford, 1937, fig. 116; Hill, 1965, pl. 10,*4;* Debrenne, 1974a, fig. 27, USNM PU86741-783, Washington, D.C.]. Outer wall compound with completely subdivided pores; inner wall with several rows of simple pores per intersept; pseudotaenial network coarsely porous. *lower Cambrian (Atd.3–Atd.4):* Australia.——Fig. 633*a–b*. **C. confertus*, Ajax Limestone, Atdabanian, Paint Mine, South Australia, Australia, holotype, USNM PU86741-783; *a,* transverse view, ×5; *b,* longitudinal view, ×5 (Hill, 1965).

Agastrocyathus Debrenne, 1964, p. 209 [**Protopharetra gregaria* Debrenne, 1961, p. 21; OD; holotype, Debrenne, 1961, pl. 2,*5–6*, MNHN M80138, HD71, Paris]. Outer wall compound with incipient subdivision of intervallar cells; inner wall with one row of simple pores per intersept; taeniae coarsely porous, linked by synapticulae. *lower Cambrian (Atd.2–Atd.4):* South China, Morocco, Iberia.——Fig. 634*a–c*. **A. gregarius* (Debrenne), Amouslek Formation, Atdabanian, Jbel Taïssa, Morocco, holotype, MNHN M80138, HD71; *a,* longitudinal section of modular skeleton, ×3; *b,* transverse section of modular skeleton, ×4; *c,* detail of outer wall in tangential section, ×10 (Debrenne, Zhuravlev, & Kruse, 2002).

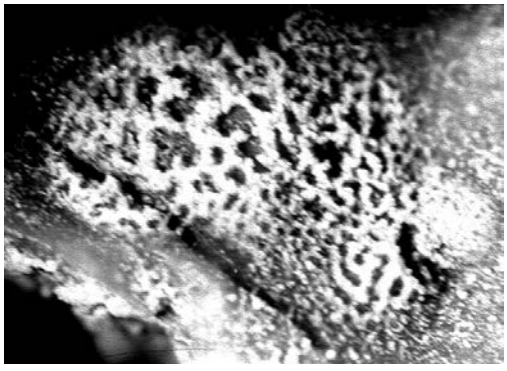
Gabrielsocyathus Debrenne, 1964, p. 248 [**Metacoscinus gabrielsensis* Okulitch, 1955b, p. 61; OD; holotype, Okulitch, 1955b, pl.

a

Sigmofungia



b



c

FIG. 631. Archaeocyathidae (p. 1058).

FIG. 632. Archaeosyconidae (p. 1058).

1,*1,2,5*, GSC 12357, Ottawa]. Outer wall compound with completely subdivided pores; inner wall with several rows of simple pores per intersept; taeniae finely porous, linked by synapticulae; simple segmented tabulae. *lower Cambrian (Bot.2):* Canada, United States.——FIG. 635,*1a–c*. **G. gabrielsensis* (OKULITCH), Atan Group, Botoman, McDame Lake, British Columbia, Canada, holotype, GSC 12357; *a,* transverse section, ×2.5; *b,* longitudinal section, ×2.5; *c,* transverse section (outer wall at bottom), ×2.5 (Debrenne, Zhuravlev, & Kruse, 2002).

Metacyathellus DEBRENNE & ZHURAVLEV, 1990, p. 302 [**Metaldetes*? *caribouensis* HANDFIELD, 1971, p. 64; OD; holotype, HANDFIELD, 1971, pl. 11,*2*, GSC 25367, Ottawa]. Outer wall compound with completely subdivided pores; inner wall with one to two rows of simple pores per intersept; taeniae coarsely porous; compound segmented tabulae. *lower Cambrian (Atd.4–Bot.3):* Australia, Antarctica, Falkland Islands (allochthonous), South China, Canada, United States.——FIG. 635,*2a–c*. **M. caribouensis* (HANDFIELD), Sekwi Formation, Botoman; *a,* Caribou Pass, Northwest Territories, Canada, holotype, GSC 25367, transverse section, ×4 (Handfield, 1971); *b,* Mackenzie Mountains, Northwest Territories, Canada, specimen GSC 90187, detail of outer wall in tangential section, ×10 (Voronova & others, 1987); *c,* Caribou Pass, Northwest Territories, Canada, holotype, GSC 25367, longitudinal section, ×6 (Handfield, 1971). [*2a, 2c* are reproduced with the permission of the Minister of Public Works and Government Services Canada, 2006 and courtesy of Natural Resources Canada, Geological Survey of Canada.]

Spinosocyathus ZHURAVLEVA, 1960b, p. 276 [**S. maslennikovae*; OD; holotype, ZHURAVLEVA, 1960b, pl. 25,*1b*, TsSGM 205/134, Novosibirsk]. Outer wall compound with incipient pore subdivision; inner wall with one row of simple pores per intersept; pseudotaenial network coarsely porous; compound segmented tabulae. *lower Cambrian (Tom.2–Atd.2):* Siberian Platform, Mongolia, Iberia.——FIG. 636,*1a–b*. **S. maslennikovae*, Pestrotsvet Formation, Tommotian, Churan, Lena River, Sakha (Yakutia), Russia; *a,* holotype, TsSGM 205/134, transverse section (outer wall at bottom), ×8 (Zhuravleva, 1960b); *b,* oblique longitudinal section of modular skeleton, specimen TsSGM 144-32/4, ×3 (Debrenne, Zhuravlev, & Kruse, 2002).

Spirillicyathus R. BEDFORD & J. BEDFORD, 1937, p. 30 [**S. tenuis*; OD; holotype, R. BEDFORD & J. BEDFORD, 1937, fig. 118; DEBRENNE, 1974a, fig. 10, USNM PU493967, specimen 358, Washington, D.C.] [=*Spiralicyathus* R. BEDFORD & J. BEDFORD, 1937, fig. 118 caption, *nom. null.*]. Outer wall compound with completely subdivided pores; inner wall with one to two rows of simple pores per intersept; pseudotaenial network coarsely porous. *lower Cambrian (Atd.4–Bot.1):* Australia, South China.——FIG. 636,*2a–c*. **S. tenuis*, Ajax Limestone, Atdabanian, Paint Mine, South Australia, Australia; *a–b,* holotype, USNM PU493967, specimen 358; *a,* transverse view, ×9; *b,* longitudinal view, ×9 (Debrenne, 1974a); *c,* Wilkawillina Limestone, Atdabanian, Wilkawillina Gorge, South Australia, Australia, specimen SAM P21741, tangential section of outer wall, ×10 (Gravestock, 1984).

Tabulacyathellus MISSARZHEVSKIY in REPINA & others, 1964, p. 249 [**T. bidzhaensis*; OD; holotype, REPINA & others, 1964, pl. 7,*4–6*, PIN 4297/22, Moscow]. Outer wall compound with completely subdivided pores; inner wall tabular with several rows of simple pores per intersept; pseudotaenial network coarsely porous; compound segmented tabulae. *lower Cambrian (Atd.2):* Altay Sayan, Tuva, Mongolia.——FIG.

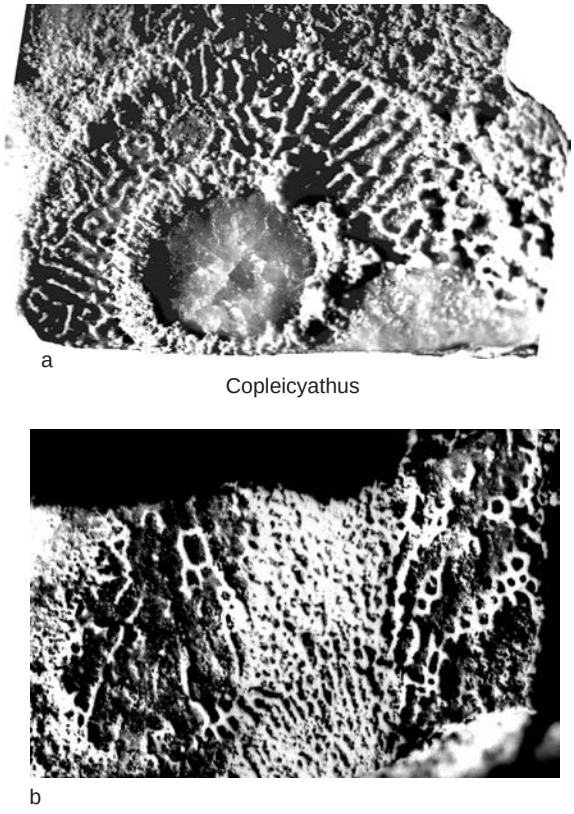


FIG. 633. Copleicyathidae (p. 1058).

637*a–c*. **T. bidzhaensis*, Usa Formation, Atdabanian, Sukhie Solontsy Valley, Batenev Range, Kuznetsk Alatau, Russia, holotype, PIN 4297/22; *a,* tangential section of outer wall, ×5; *b,* longitudinal section (outer wall to left), ×5; *c,* transverse section, ×5 (Repina & others, 1964).

Family JUGALICYATHIDAE Gravestock, 1984

[Jugalicyathidae GRAVESTOCK, 1984, p. 114]

Inner wall with bracts, fused bracts or pore tubes. *lower Cambrian (Atd.4–Bot.2).*

Jugalicyathus GRAVESTOCK, 1984, p. 114 [**J. tardus*; OD; holotype, GRAVESTOCK, 1984, fig. 56H–I, SAM P21747, Adelaide]. Outer wall compound with incipient subdivision of intervallar cells; inner wall with one row of pores per intersept, bearing upwardly projecting, straight pore tubes; pseudosepta finely porous. *lower Cambrian (Atd.4):* Australia.——FIG. 638,*1a–b*. **J. tardus*; *a,* Wilkawillina Limestone, Atdabanian, Wilkawillina Gorge, South Australia, Australia, paratype, SAM P21749, oblique transverse section, ×8 (Debrenne, Zhuravlev, & Kruse, 2002); *b,* Ajax Limestone, Atdabanian, Mount Scott Range, South Australia, Australia, holotype, SAM P21747, longitudinal section, ×1 (Gravestock, 1984).

Alaskacoscinus DEBRENNE, GANGLOFF, & ZHURAVLEV in DEBRENNE & ZHURAVLEV, 1990, p. 300 [**A. tatondukensis*; OD; holotype, DEBRENNE & ZHURAVLEV, 1990, pl. 1,*5*, UAM UA2534, 2535, Fairbanks]. Outer wall tabular, compound with completely subdivided pores; inner wall tabular with one row of pores per intersept, bearing upwardly projecting, S-shaped pore tubes; pseudosepta finely porous; segmented tabulae with subdivided pores. *lower Cambrian (Bot.2):* United States.——FIG. 638,*2a–b*. **A. tatondukensis*, Adams Argillite, Botoman, Tatonduk River, Alaska, United States; *a,* holotype, UAM UA2534, longitudinal section (outer wall to right), ×4; *b,* paratype, UAM UA2536, longitudinal section, ×5 (Debrenne & Zhuravlev, 1990).

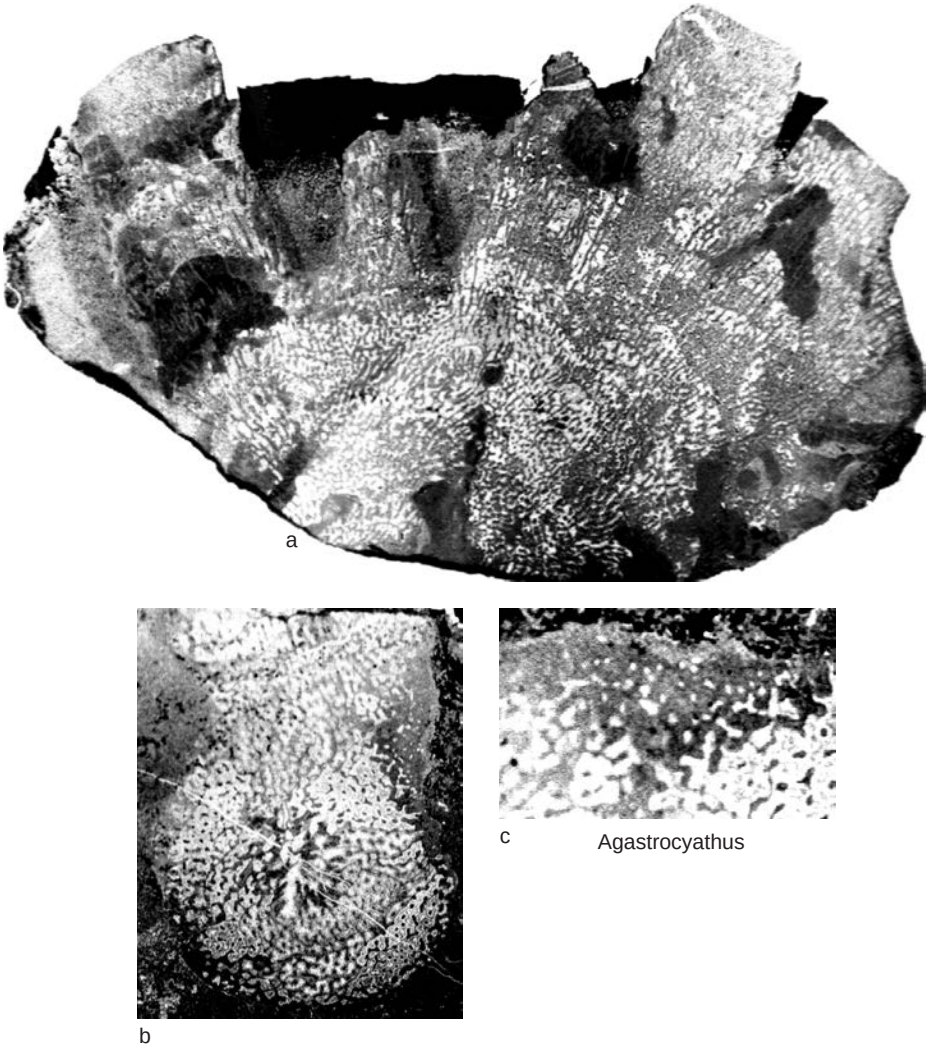


FIG. 634. Copleicyathidae (p. 1058).

Family METACYATHIDAE R. Bedford & W. R. Bedford, 1934

[Metacyathidae R. BEDFORD & W. R. BEDFORD, 1934, p. 5] [=Metacoscinidae R. BEDFORD & W. R. BEDFORD, 1936, p. 18; =Cambrocyathidae OKULITCH, 1937a, p. 251; =Cambrocyathinae OKULITCH, 1937a, p. 251, *nom. transl.* DEBRENNE, 1964, p. 218, *ex* Cambrocyathidae OKULITCH, 1937a, p. 251; =Metaldetinae DEBRENNE, 1964, p. 218; =Metafungiidae DEBRENNE, 1974a, p. 216]

Inner wall compound. *lower Cambrian (Atd.4–Bot.3).*

Metaldetes TAYLOR, 1910, p. 151 [**M. cylindricus*; M; holotype, TAYLOR, 1910, pl. 15, photo 86–88, fig. 11, 37, 38; DEBRENNE, 1974a, fig. 21a–b, M, SAM T1592A, Adelaide] [=*Metafungia* R. BEDFORD & W. R. BEDFORD, 1934, p. 5 (type, *M. reticulata*, M); =*Metacyathus* R. BEDFORD & W. R. BEDFORD, 1934, p. 5 (type, *M. taylori*, M, =*Archaeocyathus dissepimentalis* TAYLOR, 1910, p. 128); =*Metacoscinus* R. BEDFORD & W. R. BEDFORD, 1934, p. 6 (type, *M. reteseptatum*, M, =*Archaeocyathus retesepta* TAYLOR, 1910, p. 120); =*Cambrocyathus* OKULITCH, 1937a, p. 251 (type, *Archaeocyathus profundus* BILLINGS, 1861, p. 4, OD); =*Metethmophyllum* OKULITCH, 1943, p. 78 (type, *Ethmophyllum meeki* WALCOTT, 1889, p. 34, OD); =*Bedfordcyathus* VOLOGDIN, 1957a, p. 182 (type,

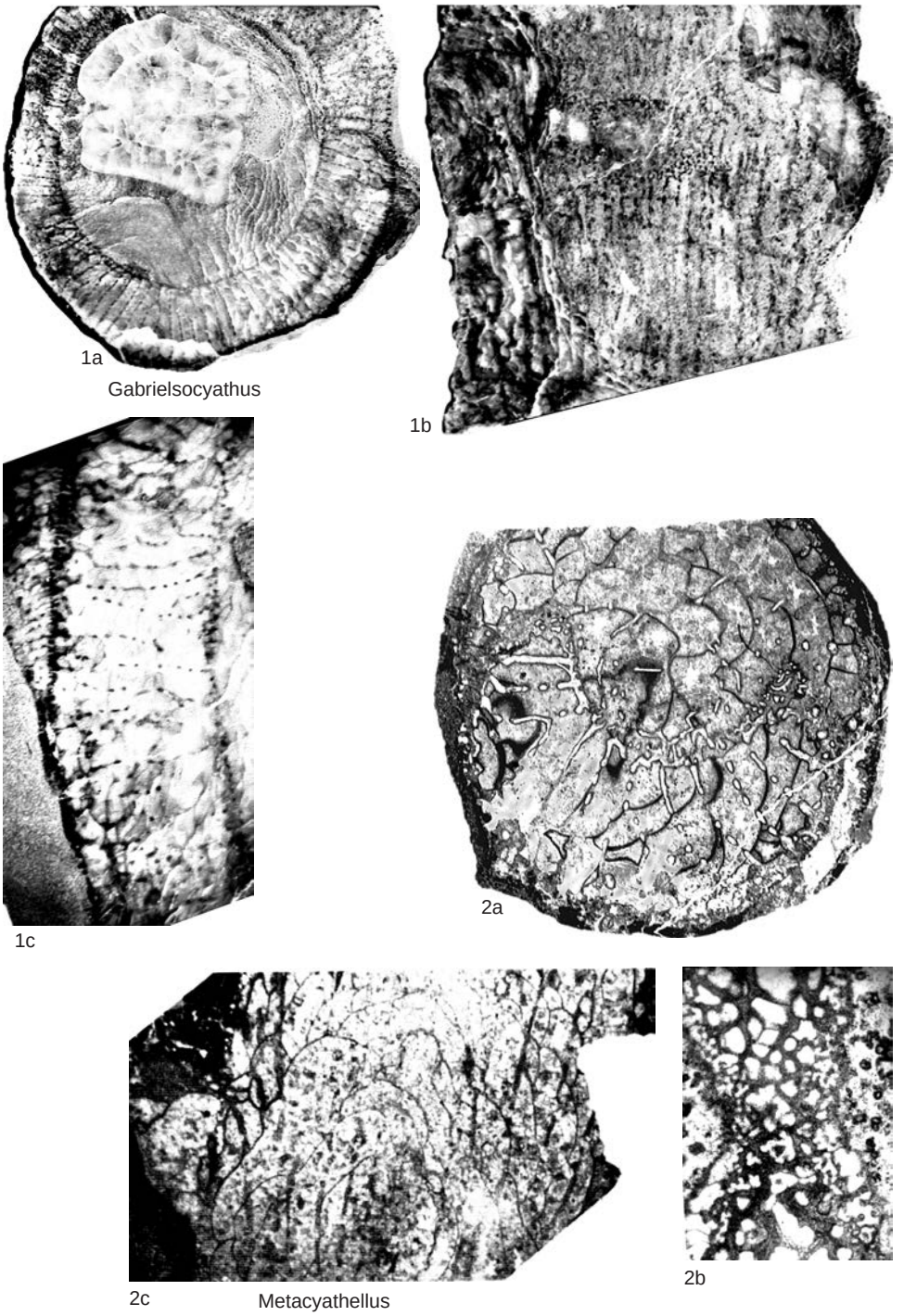


FIG. 635. Copleicyathidae (p. 1058–1060).

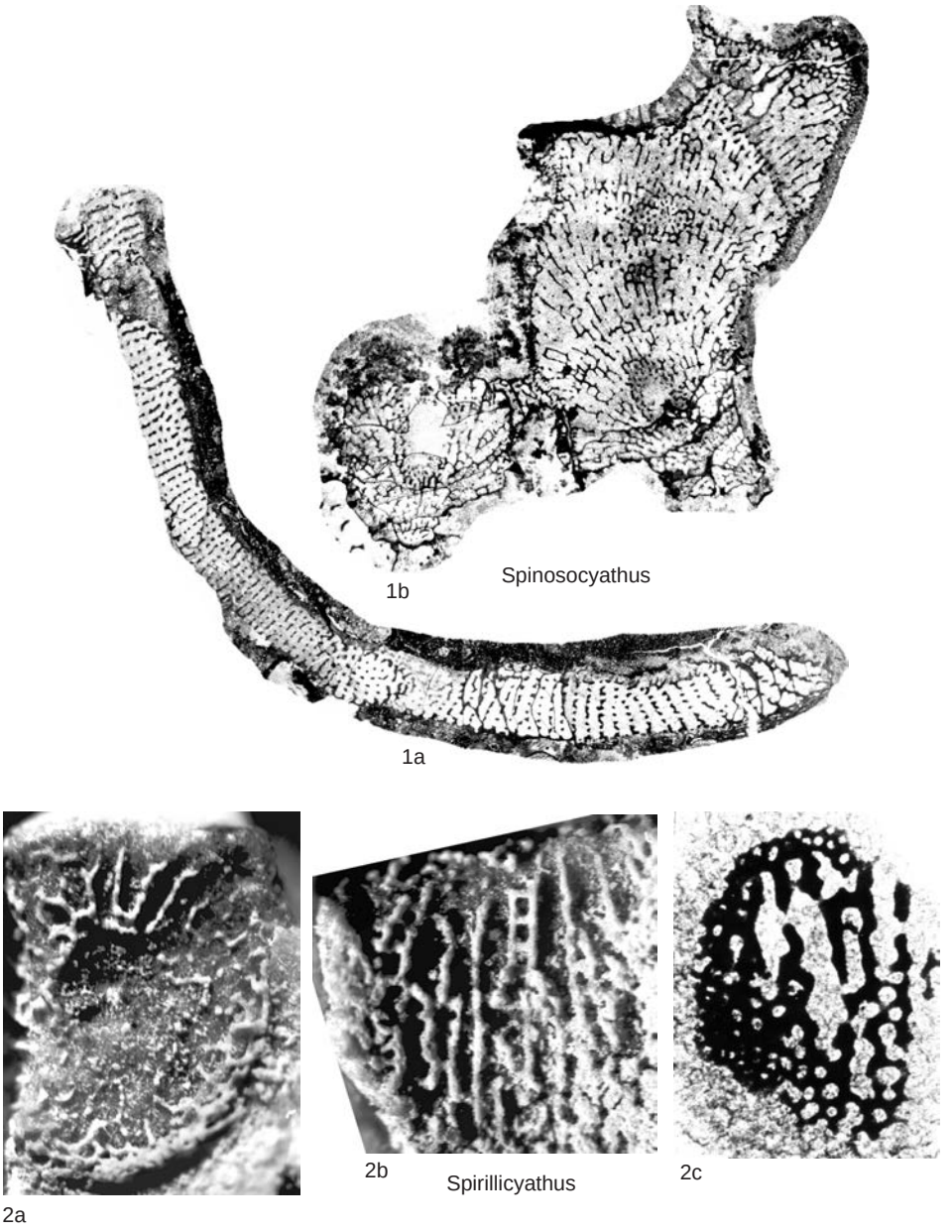


FIG. 636. Copleicyathidae (p. 1060).

Metacyathus irregularis R. BEDFORD & W. R. BEDFORD, 1934, p. 6, M, =*Archaeocyathus dissepimentalis* TAYLOR, 1910, p. 128); =*Praefungia* DEBRENNE in ZHURAVLEVA, 1974b, p. 42, *nom. correct*. DEBRENNE, 1974a, p. 227, *pro Pruefungia, lapsus calami* (type, *Metaldetes superbus* R. BEDFORD & W. R. BEDFORD, 1936, p. 18, OD), for discussion, see DEBRENNE & ZHURAVLEV, 1992b, p. 127]. Outer wall compound with completely subdivided pores; inner wall compound with several rows of completely subdivided pores per intersept; taeniae coarsely porous, linked by synapticulae in early ontogenetic stages but rarely so in mature cups; compound segmented tabulae. *lower Cambrian (Atd.4–Bot.3):* Far East, Australia, Antarctica, Canada, United States, Mexico.——FIG. 639*a–e*. **M. cylindricus*, Wilkawillina Limestone, Botoman, Wilson, South Australia, Australia, holotype, SAM T1592A; *a,* transverse section, ×4; *b,* detail of inner wall in transverse

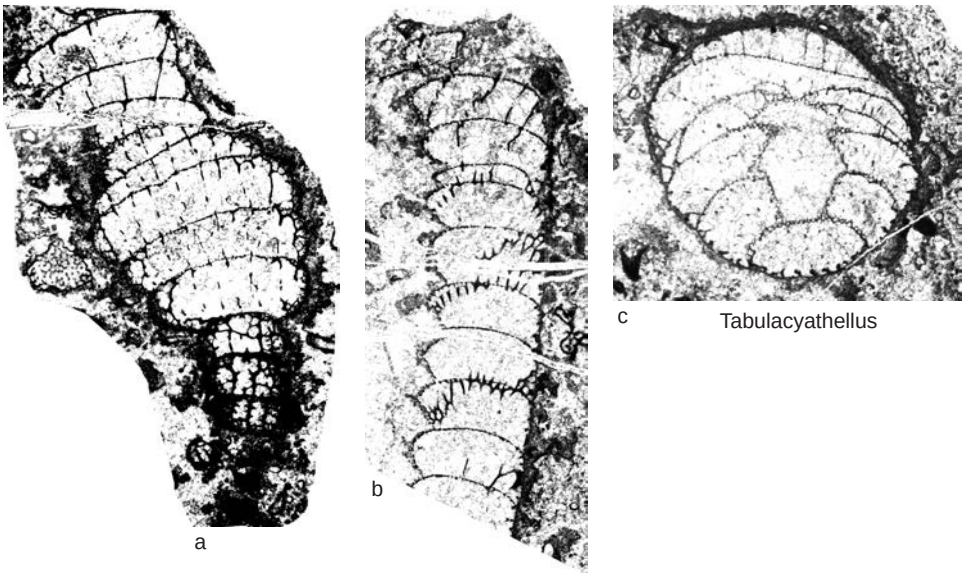


FIG. 637. Copleicyathidae (p. 1060–1061).

section, ×8; *c,* detail of outer wall in transverse section, ×8; *d,* detail of taenia in longitudinal section, ×8; *e,* longitudinal section of modular skeleton, ×4 (Debrenne, Zhuravlev, & Kruse, 2002).

Changicyathus DEBRENNE & ZHURAVLEV, 1990, p. 301 [**Cambrocyathellus tenuicaulus* ZHANG & YUAN, 1985, p. 523; OD; holotype, ZHANG & YUAN, 1985, pl. 2,*6;* DEBRENNE & ZHURAVLEV, 1990, pl. 1,*7,* NIGP 82277, specimen 17f(10-14), Nanjing]. Outer wall compound with completely subdivided pores; inner wall compound with incipient pore subdivision; taeniae coarsely porous; compound segmented tabulae. *lower Cambrian (Bot.1):* ?Tajikistan, South China.——FIG. 640. **C. tenuicaulus* (ZHANG & YUAN), Xiannudong Formation, Botoman, Nanzhen, Sichuan, China, holotype, NIGP 82277, specimen 17f(10-14), oblique longitudinal section of modular skeleton, ×6 (Debrenne & Zhuravlev, 1990).

Superfamily NAIMARKCYATHOIDEA Wrona & Zhuravlev, 1996

[Naimarkcyathoidea WRONA & ZHURAVLEV, 1996, p. 28]

Outer wall pustular. *lower Cambrian (Bot.3).*

Family NAIMARKCYATHIDAE Wrona & Zhuravlev, 1996

[Naimarkcyathidae WRONA & ZHURAVLEV, 1996, p. 29]

Inner wall with bracts, fused bracts or pore tubes. *lower Cambrian (Bot.3).*

Naimarkcyathus WRONA & ZHURAVLEV, 1996, p. 29 [**N. elenae*; OD; holotype, WRONA & ZHURAVLEV, 1996, pl. 7,*2,* ZPAL Ac.I/M10DI, Warsaw]. Inner wall with one row of pores per intersept, bearing upwardly projecting, straight pore tubes; pseudotaenial network coarsely porous. *lower Cambrian (Bot.3):* Antarctica.——FIG. 641*a–b*. **N. elenae*, Polonez Cove Formation (allochthonous), Botoman, Mazurek Point, King George Island, South Shetland Islands, Antarctica; *a,* holotype, ZPAL Ac.I/M10DI, transverse section, ×5; *b,* paratype, ZPAL Ac.I/M10CI, longitudinal section, ×5 (Wrona & Zhuravlev, 1996).

Superfamily WARRIOOTACYATHOIDEA Debrenne & Zhuravlev, 1992

[Warriootacyathoidea DEBRENNE & ZHURAVLEV, 1992b, p. 115]

Outer wall with canals. *lower Cambrian (Atd.3–Atd.4).*

Family WARRIOOTACYATHIDAE Debrenne & Zhuravlev, 1992

[Warriootacyathidae DEBRENNE & ZHURAVLEV, 1992b, p. 115]

Inner wall with bracts, fused bracts or pore tubes. *lower Cambrian (Atd.3–Atd.4).*

Warriootacyathus GRAVESTOCK, 1984, p. 126 [**W. wilkawillinensis*; OD; holotype, GRAVESTOCK, 1984, fig. 62A,D–F, SAM P21806-1, Adelaide]. Outer wall with horizontal to upwardly projecting, straight canals; inner wall with one row of pores

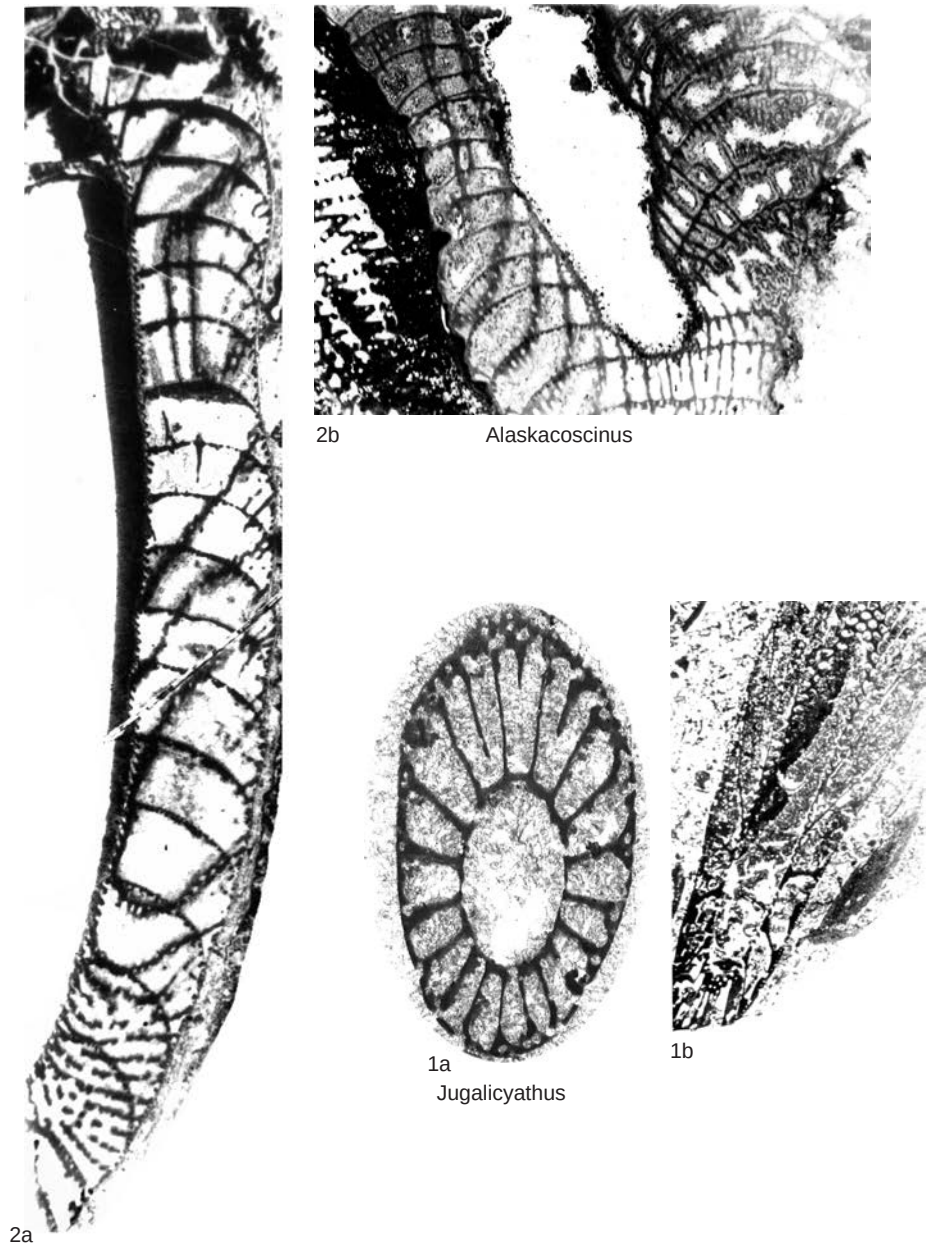


FIG. 638. Jugalicyathidae (p. 1061).

per intersept, bearing upwardly projecting, straight to waved pore tubes; pseudosepta coarsely porous. *lower Cambrian (Atd.3–Atd.4):* Australia.——FIG. 642*a–c*. **W. wilkawillinensis*, Wilkawillina Limestone, Atdabanian, Wilkawillina Gorge, South Australia, Australia, holotype, SAM P21806-1; *a,* tangential section of outer wall, ×7; *b,* tangential section of inner wall, ×3; *c,* longitudinal section of septum (outer wall to right), ×3 (Gravestock, 1984).

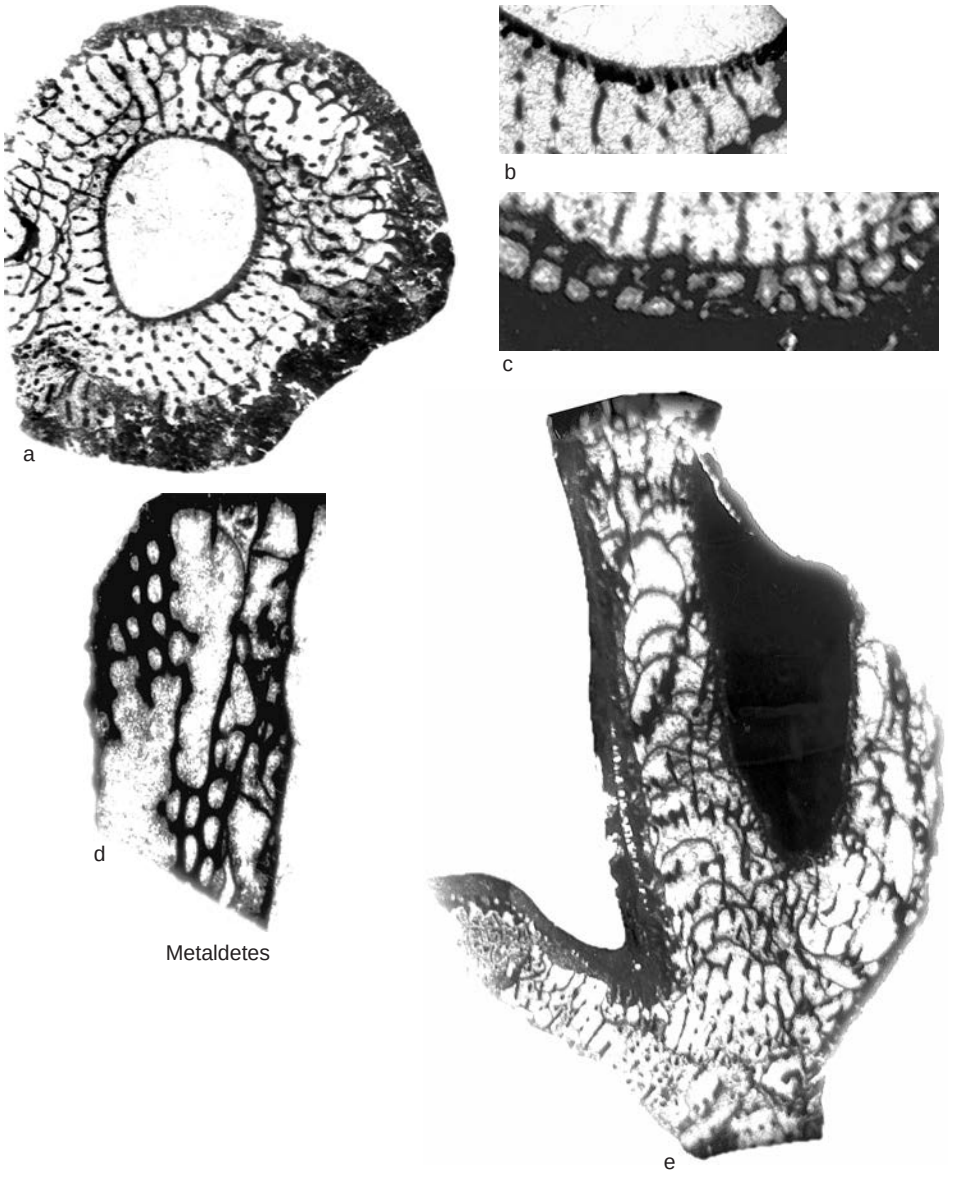


FIG. 639. Metacyathidae (p. 1062–1065).

Superfamily BELTANACYATHOIDEA Debrenne, 1974

[*nom. correct.* DEBRENNE & ZHURAVLEV, 1992b, p. 115, *pro* Beltanacyathacea GRAVESTOCK, 1984, p. 123, *nom. transl. ex* Beltanacyathidae DEBRENNE, 1974a, p. 243] [=Beltanacyathidae DEBRENNE, 1970a, p. 30, *nom. nud.*]

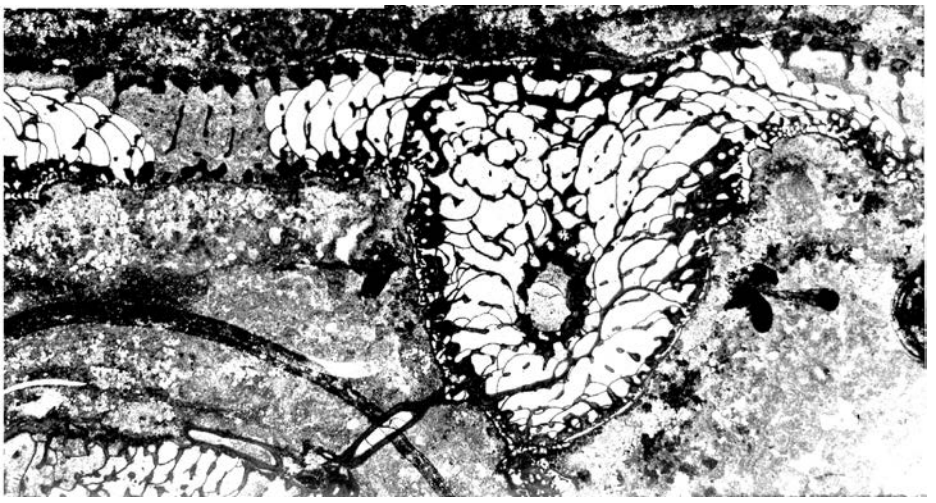
Outer wall with subdivided canals. *lower Cambrian (Atd.3–Bot.3).*

Family MAIANDROCYATHIDAE Debrenne, 1974

[Maiandrocyathidae DEBRENNE, 1974a, p. 235]

Inner wall with simple pores. *lower Cambrian (Bot.3).*

Maiandrocyathus DEBRENNE in ZHURAVLEVA, 1974a, p. 209 [**Metacoscinus insigne* R. BEDFORD & W. R. BEDFORD, 1936, p. 18; OD; holotype, R. BEDFORD



Changicyathus

FIG. 640. Metacyathidae (p. 1065).

& W. R. BEDFORD, 1936, fig. 84; DEBRENNE, 1974a, fig. 28, M, SAM P986-167, -168, Adelaide]. Inner wall with one to two rows of simple pores per intersept; taeniae coarsely porous. *lower Cambrian (Bot.3):* Australia.——FIG. 643,*1a–b*. **M. insigne* (R. BEDFORD & W. R. BEDFORD), Ajax Limestone, Botoman, Ajax Mine, South Australia, Australia, holotype, SAM P986-167, -168; *a,* tangential view of outer wall, ×3; *b,* longitudinal view of septum and exocyathoid buttress (outer wall to right), ×3 (Debrenne, Zhuravlev, & Kruse, 2002).

Ataxiocyathus DEBRENNE in ZHURAVLEVA, 1974a, p. 52 [**Paranacyathus grandis* R. BEDFORD & J. BEDFORD, 1937, p. 34; OD; holotype, R. BEDFORD & J. BEDFORD, 1937, fig. 140; DEBRENNE, 1974c, pl. 20,*3–4,* M, USNM PU86821, specimen 311, Washington, D.C.]. Inner wall with one row of simple pores per intersept; pseudosepta finely porous. *lower Cambrian (Bot.3):* Australia.——FIG. 643,2*a–c*. **A. grandis* (R. BEDFORD & J. BEDFORD), Ajax Limestone, Botoman, Ajax Mine, South Australia, Australia, holotype, USNM PU86821, specimen 311; *a,* transverse view, ×5 (Debrenne, Zhuravlev, & Kruse, 2002); *b,* longitudinal view of septum (outer wall to left), ×6 (Debrenne, Zhuravlev, & Kruse, 2012b); *c,* tangential view of outer wall, ×6 (Debrenne, 1974c).

Family BELTANACYATHIDAE Debrenne, 1974

[Beltanacyathidae DEBRENNE, 1974a, p. 243] [=Beltanacyathidae DEBRENNE, 1970a, p. 30, *nom. nud.*]

Inner wall with bracts, fused bracts, or pore tubes. *lower Cambrian (Atd.3–Atd.4).*

Beltanacyathus R. BEDFORD & J. BEDFORD, 1936, p. 23 [**B. ionicus*; OD; lectotype, R. BEDFORD & J. BEDFORD, 1936, fig. 95–96; HILL, 1965, pl. 6,*3;* SD HILL, 1965, p. 89, USNM PU86716-271, Washington, D.C.; =*Archaeocyathus wirrialpensis* TAYLOR, 1910, p. 124; holotype, TAYLOR, 1910, pl. 8, photo 43–44; DEBRENNE, 1974a, fig. 33b; M, SAM T1581A-E, Adelaide] [=*Fridaycyathus* GRAVESTOCK, 1984, p. 125 (type, *F. biserialis*, OD); =*Bayleicyathus* GRAVESTOCK, 1984, p. 131 (type, *B. bowmani*, OD), for discussion, see DEBRENNE & ZHURAVLEV, 1992b, p. 122]. Inner wall with one row of pores per intersept, bearing upwardly projecting, straight pore tubes; pseudosepta finely porous; segmented tabulae. *lower Cambrian (Atd.3–Atd.4):* Australia.——FIG. 644*a–d*. **B. wirrialpensis* (TAYLOR); *a–b,* holotype, Wilkawillina Limestone, Atdabanian, Wirrealpa Mine, South Australia, Australia, SAM T1581A-E; *a,* transverse section (outer wall at top), ×2; *b,* longitudinal section (outer wall to left), ×2.5 (Taylor, 1910); *c–d,* lectotype [=*B. ionicus*], Ajax Limestone, Atdabanian, Paint Mine, South Australia, Australia, USNM PU86716-271; *c,* transverse view, ×2; *d,* longitudinal view, ×2 (Hill, 1965).

Superfamily TABELLAECYATHOIDEA Fonin, 1963

[*nom. transl.* DEBRENNE & ZHURAVLEV, 1992b, p. 116, *ex* Tabellaecyathidae FONIN, 1963, p. 15] [=Taeniaecyathellacea KONYUSHKOV, 1972, p. 141]

Outer wall tabellar. *lower Cambrian (Bot.2–Bot.3).*

Family TABELLAECYATHIDAE Fonin, 1963

[Tabellaecyathidae Fonin, 1963, p. 15] [=Taeniaecyathellidae Konyushkov, 1972, p. 142; =Karakolocyathidae Konyushkov, 1972, p. 142]

Inner wall with bracts, fused bracts, or pore tubes. *lower Cambrian (Bot.2–Bot.3).*

Taeniaecyathellus Zhuravleva, 1960a, p. 45 [**T. semenovi*; OD; holotype, Zhuravleva, 1960a, fig. 1i–k, TsSGM 273/7, Novosibirsk] [=*Tabellaecyathus* Fonin, 1963, p. 15 (type, *T. totus*, OD); =*Cambronanus* Fonin, 1963, p. 19 (type, *C. multicavitatus*, OD); =*Karakolocyathus* Konyushkov, 1972, p. 142 (type, *K. loculatus*, OD; =*Tabellaecyathus totus* Fonin, 1963, p. 16), for discussion, see Debrenne & Zhuravlev, 1992b, p. 131]. Inner wall with several rows of pores per intersept, bearing upwardly projecting, straight pore tubes; dictyonal network. *lower Cambrian (Bot.2–Bot.3):* Altay Sayan.——Fig. 645*a–b*. **T. semenovi*, Verkhnemonok Formation, Botoman, Malyy Karakol River, West Sayan, Altay Sayan, Russia, holotype, TsSGM 273/7; *a,* oblique longitudinal section, ×5; *b,* detail of outer wall in tangential section, ×21 (Debrenne, Zhuravlev, & Kruse, 2002).

Suborder DICTYOFAVINA Debrenne, 1991

[Dictyofavina Debrenne, 1991, p. 219]

Skeleton solitary or modular, latter as branching or massive pseudocolonies (both by intercalicular budding); intervallum with calicles. *lower Cambrian (Atd.1–Bot.2).*

Superfamily USLONCYATHOIDEA Fonin, 1966

[*nom. transl.* Debrenne, Zhuravlev, & Kruse, 2002, p. 1679, *ex* Usloncyathidae Fonin in Vologdin & Fonin, 1966, p. 187] [=Dictyofavoidea Debrenne & Zhuravlev, 1992a, p. 596]

Outer wall simple. *lower Cambrian (Atd.1–Bot.2).*

Family USLONCYATHIDAE Fonin, 1966

[Usloncyathidae Fonin in Vologdin & Fonin, 1966, p. 187] [=Dictyofavidae Debrenne & Zhuravlev, 1992a, p. 596]

Inner wall with simple pores. *lower Cambrian (Atd.1–Bot.2).*

Usloncyathus Fonin in Vologdin & Fonin, 1966, p. 188 [**U. miculus*; OD; holotype, Vologdin & Fonin, 1966, fig. 1a, PIN 2486/143, Moscow]

Fig. 641. Naimarkcyathidae (p. 1065).

[=*Falsocyathus* Fonin in Vologdin & Fonin, 1966, p. 189 (type, *F. vastulus*, OD; =*U. miculus* Fonin in Vologdin & Fonin, 1966, p. 188); =*Nostrocyathus* Fonin in Vologdin & Fonin, 1966, p. 189 (type, *N. aculeatus*, OD; =*U. miculus* Fonin in Vologdin & Fonin, 1966, p. 188); =*Cavocyathus* Fonin in Vologdin & Fonin, 1966, p. 189 (type, *C. pusilus*; OD; =*U. miculus* Fonin in Vologdin & Fonin, 1966, p. 188), for discussion, see Debrenne & Zhuravlev, 1992b, p. 132; =*Dictyofavus* Gravestock, 1984, p. 98 (type, *D. obtusus*, OD)]. Outer and inner walls rudimentary; calicles hexagonal in cross section with several pore rows per facet. *lower Cambrian (Atd.1–Atd.4):* Altay Sayan, Tuva, Mongolia, Transbaikalia, Far

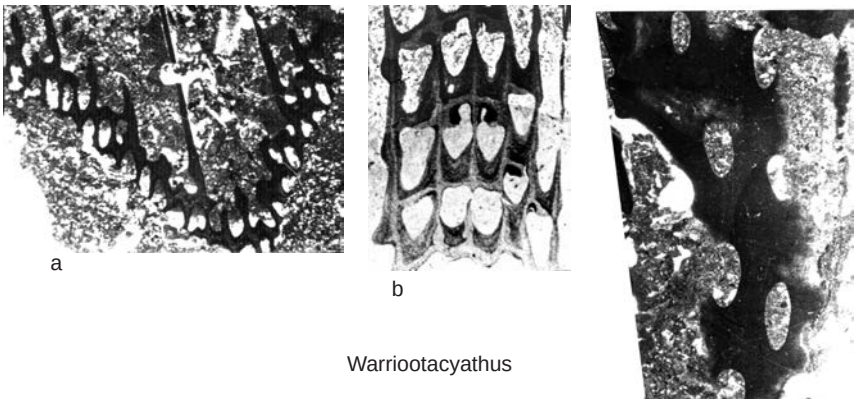


FIG. 642. Warriootacyathidae (p. 1065–1066).

East, Australia, South China.——FIG. 646,*1.* **U. miculus*, Bystraya Formation, Atdabanian, Uslon Valley, Transbaikalia, Russia, holotype, PIN 2486/143, longitudinal section, ×8 (Vologdin & Fonin, 1966).

Kechikacyathus DEBRENNE & ZHURAVLEV, 1992a, p. 598 [**K. natlaensis*; OD; holotype, DEBRENNE & ZHURAVLEV, 1992a, pl. 1,*3*, GSC 90166, Ottawa]. Outer wall basic; inner wall rudimentary; calicles hexagonal in cross section with one pore row per facet. *lower Cambrian (Bot.1–Bot.2):* Canada.——FIG. 646,*2a–b*. **K. natlaensis*, Sekwi Formation, Botoman; *a,* Kechika River, British Columbia, Canada, paratype, GSC 103939, GAM-78-G, detail of outer wall in tangential section, ×10; *b,* Natla, Mackenzie Mountains, Northwest Territories, Canada, holotype, GSC 90166, longitudinal section, ×5 (Debrenne & Zhuravlev, 1992a).

Zunyicyathus DEBRENNE, KRUSE, & ZHANG, 1991, p. 286 [**Agastrocyathus grandis* YUAN & ZHANG, 1980, p. 387; OD; *nom. correct.* DEBRENNE, KRUSE, & ZHANG, 1991, p. 286, *pro Agastrocyathus grandus* YUAN & ZHANG, 1980, p. 387; holotype, YUAN & ZHANG, 1980, pl. 1,*3*, NIGP 56292, Nanjing]. Outer and inner walls rudimentary; calicles tetragonal in cross section with one pore row per facet. *lower Cambrian (Bot.1–Bot.2):* Tajikistan, South China, United States.——FIG. 647. **Z. grandis* (YUAN & ZHANG), Jindingshan (Chintingshan) Formation, Botoman, Jindingshan, Guizhou, China, specimen MNHN 85103, longitudinal section of modular skeleton, ×5 (Debrenne, Kruse, & Zhang, 1991).

Superfamily KERIOCYATHOIDEA Debrenne & Gangloff, 1992

[Keriocyathoidea DEBRENNE & GANGLOFF in DEBRENNE & ZHURAVLEV, 1992a, p. 598]

Outer wall concentrically porous. *lower Cambrian (Bot.1–Bot.2).*

Family KERIOCYATHIDAE Debrenne & Gangloff, 1992

[Keriocyathidae DEBRENNE & GANGLOFF in DEBRENNE & ZHURAVLEV, 1992a, p. 598] [=Keriocyathidae DEBRENNE & GANGLOFF in DEBRENNE, GANDIN, & GANGLOFF, 1990, p. 93, *nom. nud.*]

Inner wall with simple pores. *lower Cambrian (Bot.1–Bot.2).*

Keriocyathus DEBRENNE & GANGLOFF in DEBRENNE, GANDIN, & GANGLOFF, 1990, p. 93 [**K. arachnaius*; OD; holotype, DEBRENNE, GANDIN, & GANGLOFF, 1990, pl. 1,*9*, USNM 443557, specimen IR24.10, Washington, D.C.]. Inner wall basic; calicles tetragonal in cross section with one pore row per facet. *lower Cambrian (Bot.1–Bot.2):* Altay Sayan, Far East, United States.——FIG. 648*a–b*. **K. arachnaius*, Valmy Formation, Botoman, Iron Canyon, Nevada, United States; *a,* holotype, USNM 443557, specimen IR24.10, transverse section, ×7.5; *b,* paratype, USNM 443572, longitudinal section, ×7.5 (Debrenne, Gandin, & Gangloff, 1990).

Superfamily GATAGACYATHOIDEA Debrenne & Zhuravlev, 1992

[Gatagacyathoidea DEBRENNE & ZHURAVLEV, 1992a, p. 598]

Outer wall compound. *lower Cambrian (Bot.2).*

Family GATAGACYATHIDAE Debrenne & Zhuravlev, 1992

[Gatagacyathidae DEBRENNE & ZHURAVLEV, 1992a, p. 598]

Inner wall with simple pores. *lower Cambrian (Bot.2).*

Gatagacyathus DEBRENNE & ZHURAVLEV, 1992a, p. 598 [**G. mansyi*; OD; holotype, DEBRENNE

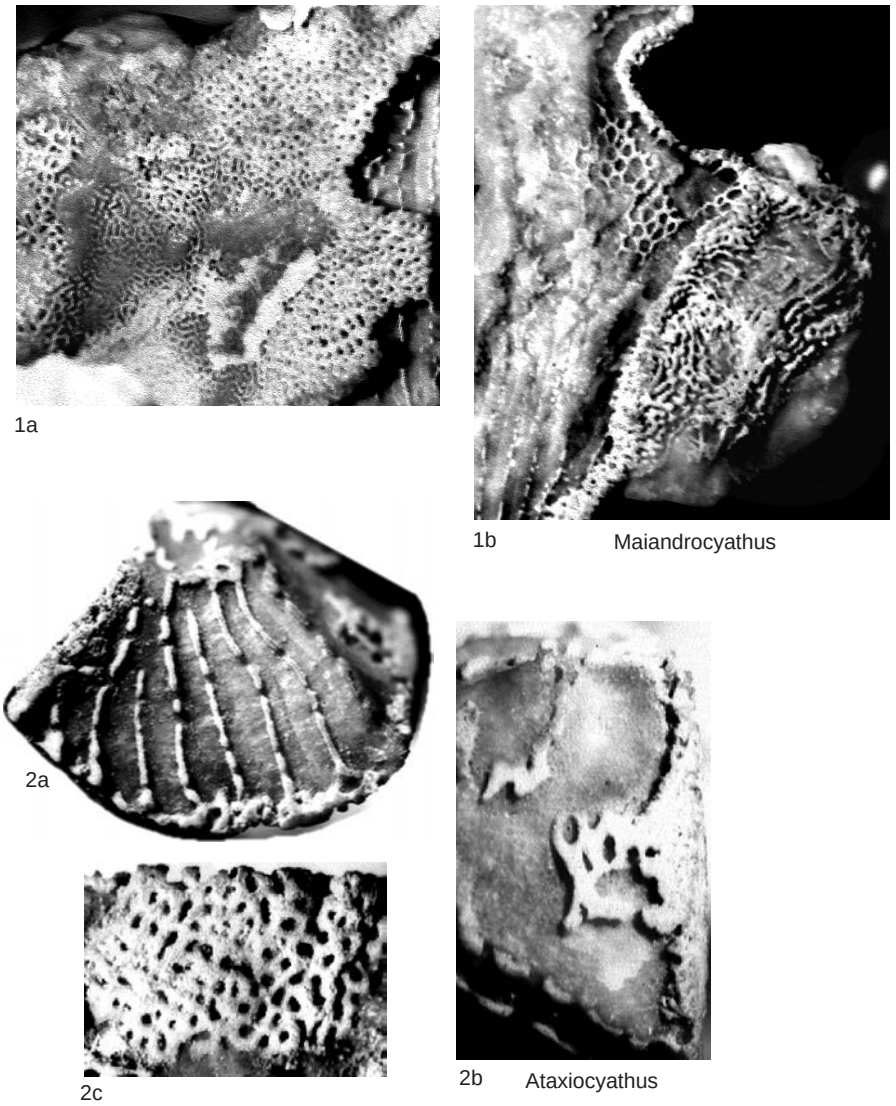


FIG. 643. Maiandrocyathidae (p. 1067–1068).

& ZHURAVLEV, 1992a, pl. 1,*4,* GSC 103942, specimen GAM76.8G.XI.3L, Ottawa]. Outer wall compound with incipient pore subdivision; inner wall rudimentary; calicles hexagonal in cross section with one pore row per facet. *lower Cambrian (Bot.2):* Canada, United States.——FIG. 649. **G. mansyi*, Rosella Formation, Botoman, Kechika River, British Columbia, Canada, holotype, GSC 103942, specimen GAM76.8G.XI.3L, longitudinal section, ×3.5 (Debrenne, Zhuravlev, & Kruse, 2002).

Suborder SYRINGOCNEMINA Okulitch, 1935

[*nom. correct.* DEBRENNE, ZHURAVLEV, & KRUSE, herein, *pro* Syringicnemidina KRASNOPEEVA, 1980, p. 159, *nom. transl. ex* order Syringocnemina OKULITCH, 1935b, p. 90] [=Syringocyathina DEBRENNE, 1991, p. 219]

Skeleton solitary or modular, latter as branching pseudocolonies (by longitudinal fission); intervallum with syringes. *lower Cambrian (Atd.4–Bot.3).*

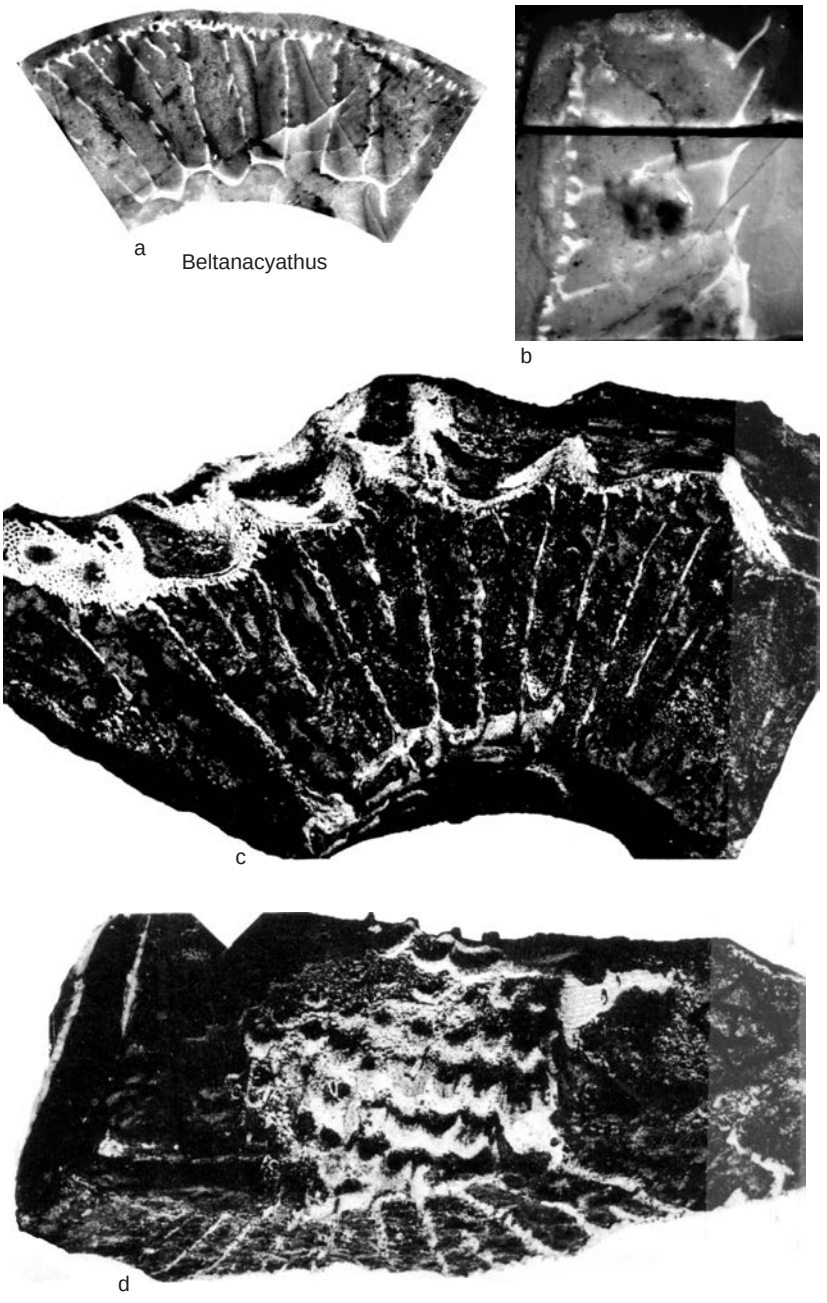


FIG. 644. Beltanacyathidae (p. 1068).

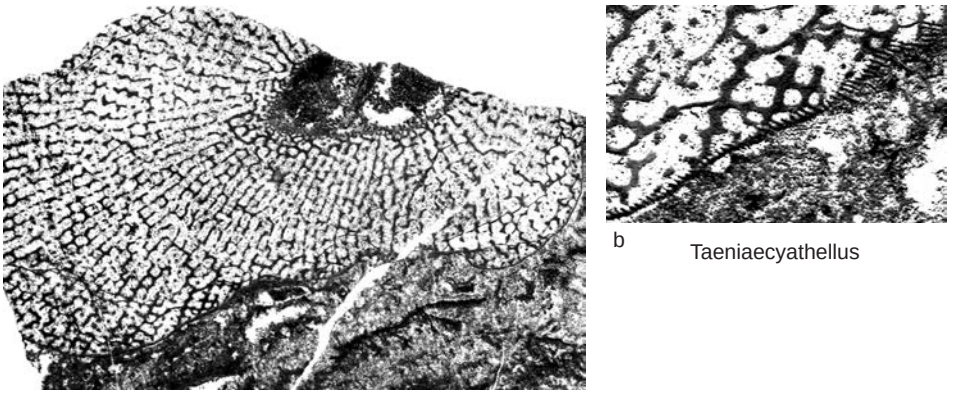


FIG. 645. Tabellaecyathidae (p. 1069).

Superfamily AULISCOCYATHOIDEA Debrenne & Zhuravlev, 1992

[Auliscocyathoidea DEBRENNE & ZHURAVLEV, 1992b, p. 117]

Outer wall simple. *lower Cambrian (Atd.4–Bot.3).*

Family AULISCOCYATHIDAE Debrenne & Zhuravlev, 1992

[Auliscocyathidae DEBRENNE & ZHURAVLEV, 1992b, p. 117]

Inner wall with simple pores. *lower Cambrian (Atd.4–Bot.3).*

Auliscocyathus DEBRENNE in ZHURAVLEVA, 1974a, p. 53 [**Spirocyathus multifidus* R. BEDFORD & W. R. BEDFORD, 1936, p. 14; OD; lectotype, R. BEDFORD & W. R. BEDFORD, 1936, fig. 65; DEBRENNE, 1974a, fig. 8a; SD DEBRENNE, 1974a, p. 199, SAM P950-81, Adelaide]. Outer and inner walls rudimentary; syringes tetragonal in cross section with one pore row per facet. *lower Cambrian (Atd.4–Bot.3):* Tuva, Australia, Antarctica.——FIG. 650*a–c*. **A. multifidus* (R. BEDFORD & W. R. BEDFORD), Ajax Limestone, Botoman, Ajax Mine, South Australia, Australia, lectotype, SAM P950-81; *a*, longitudinal view, ×5 (Debrenne, 1974a); *b,* oblique longitudinal view, ×5; *c,* detail of syringes in longitudinal intervallar view, ×8 (Debrenne, Zhuravlev, & Kruse, 2002).

Superfamily SYRINGOCNEMOIDEA Taylor, 1910

[*nom. correct.* DEBRENNE, ZHURAVLEV, & KRUSE, herein, *pro* Syringocnemidoidea DEBRENNE & ZHURAVLEV, 1992b, p. 117, *nom. transl. ex* Syringocnemidae TAYLOR, 1910, p. 113]

Outer wall concentrically porous. *lower Cambrian (Bot.1–Bot.3).*

Family TUVACNEMIDAE Debrenne & Zhuravlev, 1990

[*nom. correct.* DEBRENNE, ZHURAVLEV, & KRUSE, herein, *pro* Tuvacnemididae DEBRENNE & ZHURAVLEV, 1990, p. 300]

Inner wall with simple pores. *lower Cambrian (Bot.1–Bot.3).*

Tuvacnema DEBRENNE & ZHURAVLEV, 1990, p. 301 [**Syringocnema tannuolensis* RODIONOVA in ZHURAVLEVA & others, 1967, p. 106; OD; holotype, ZHURAVLEVA & others, 1967, pl. 58,*4*, VSEGEI 9594, St. Petersburg, not located]. Inner wall with several rows of pores per syrinx; syringes hexagonal in cross section with several pore rows per facet. *lower Cambrian (Bot.1–Bot.3):* Tuva.——FIG. 651. **T. tannuolensis* (RODIONOVA), Shangan Formation, Botoman, Shivelig-Khem River, East Tannu-Ola Range, Russia, holotype, VSEGEI 9594, transverse section, ×7 (Zhuravleva & others, 1967).

Family SYRINGOCNEMIDAE Taylor, 1910

[Syringocnemidae TAYLOR, 1910, p. 113] [=Syringocnematidae VOLOGDIN, 1928, p. 31; =Syringocnemitidae TING, 1937, p. 370; =Syringocnemididae DEBRENNE, 1964, p. 117; =Pseudosyringocnemididae DEBRENNE, 1975, p. 355]

Inner wall with bracts, fused bracts, or pore tubes. *lower Cambrian (Bot.1–Bot.3).*

Syringocnema TAYLOR, 1910, p. 153 [**S. favus*; M; holotype, TAYLOR, 1910, pl. 14, photos 78–79, M, SAM T1597A,B,E, Adelaide]. Inner wall with one row of pores per syrinx, bearing upwardly projecting, S-shaped pore tubes; syringes hexagonal in cross section with several pore rows per facet. *lower Cambrian (Bot.3):* Australia, Antarctica, ?Falkland Islands (allochthonous).——FIG. 652*a–d*. **S. favus*, Ajax Limestone, Botoman, Ajax Mine, South Australia, Australia; *a–c,* holotype, SAM T1597A,B,E; *a,* transverse view, ×3; *b,* oblique longitudinal view, ×3.5; *c,* detail of

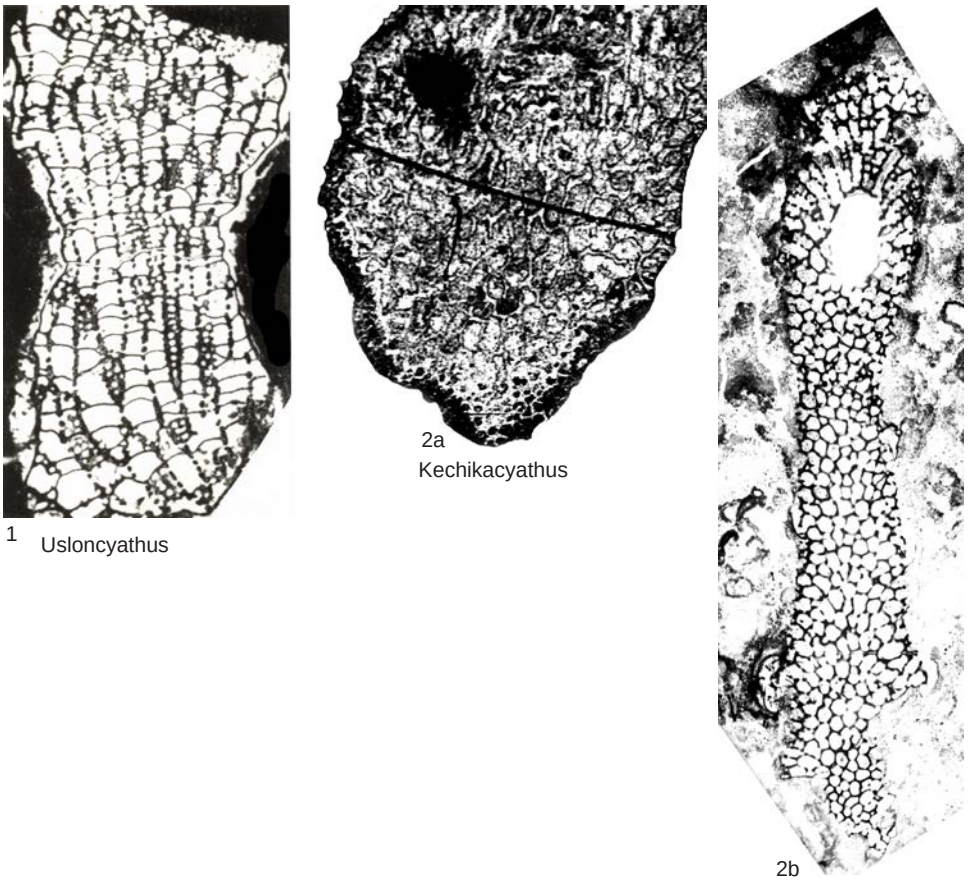


FIG. 646. Usloncyathidae (p. 1069–1070).

syringes in longitudinal view (outer wall to left), ×5; *d,* paratype, SAM T1558, detail of syringes in oblique transverse view, ×5 (Debrenne, Zhuravlev, & Kruse, 2002).

Pseudosyringocnema HANDFIELD, 1971, p. 76 [**P. uniporus*; OD; holotype, HANDFIELD, 1971, pl. 15,*3*, GSC 25392, Ottawa]. Inner wall with one row of pores per syrinx, bearing upwardly projecting, S-shaped pore tubes; syringes hexagonal in cross section with one pore row per transverse facet and several pore rows per lateral facet. *lower Cambrian (Bot.2–Bot.3):* Altay Sayan, Antarctica, Canada, United States.——FIG. 653,*1a–b*. **P. uniporus*, unnamed Sekwi Formation equivalent (map unit 5 of HANDFIELD, 1971), Botoman, Coal River, Yukon Territory, Northwest Territories, Canada, holotype, GSC 25392; *a,* longitudinal section, ×4 (Debrenne, Zhuravlev, & Kruse, 2002); *b,* oblique longitudinal section, ×4 (Handfield, 1971; reproduced with the permission of the Minister of Public Works and Government Services Canada, 2006 and courtesy of Natural Resources Canada, Geological Survey of Canada).

Syringothalamus DEBRENNE, GANGLOFF, & ZHURAVLEV in DEBRENNE & ZHURAVLEV, 1990, p. 301 [**S. crispus*; OD; holotype, DEBRENNE & ZHURAVLEV, 1990, pl. 1,*1*, UCMP D6610, Berkeley]. Inner wall with one row of pores per syrinx, bearing upwardly projecting, S-shaped fused bracts; syringes hexagonal in cross section with one pore row per facet. *lower Cambrian (Bot.1):* United States.——FIG. 653,*2a–c*. **S. crispus*, Poleta Formation, Botoman, Lida, Palmetto Mountains, Nevada, United States; *a,* holotype, UCMP D6610, detail of outer wall in tangential section, ×11 (Debrenne, Zhuravlev, & Kruse, 2002); *b,* paratype, UCMP D6620, transverse section, ×5; *c,* holotype, UCMP D6610, oblique longitudinal section, ×5 (Debrenne & Zhuravlev, 1990).

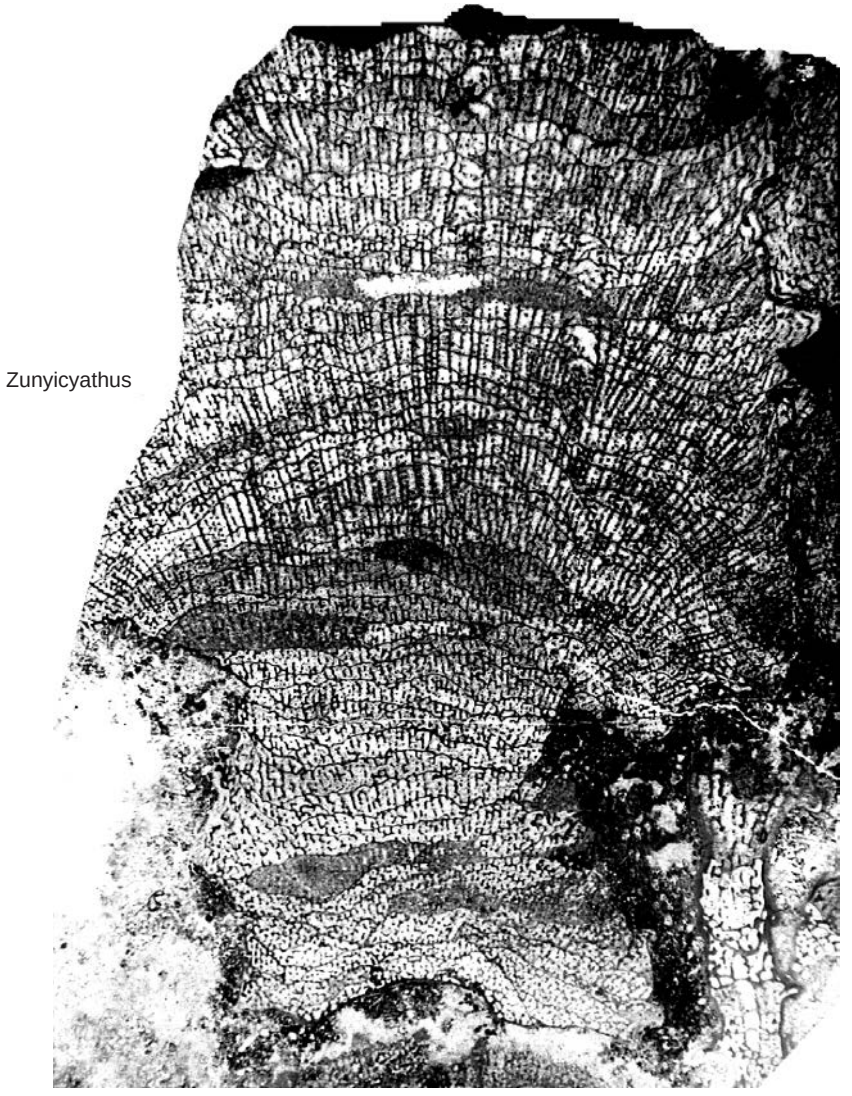


FIG. 647. Usloncyathidae (p. 1070).

Williamicyathus ZHURAVLEV in VORONOVA & others, 1987, p. 34 [**Syringocnema colvillensis* GREGGS, 1959, p. 72; OD; holotype, GREGGS, 1959, pl. 13,*6,* GSC 14317, Ottawa]. Inner wall with one row of pores per syrinx, bearing upwardly projecting, planar, fused bracts; syringes hexagonal in cross section with one pore row per transverse facet and several pore rows per lateral facet. *lower Cambrian (Bot.1–Bot.2):* Canada, United States.——FIG. 654*a–c*. **W. colvillensis* (GREGGS); *a,* Sekwi Formation, Botoman, Mackenzie Mountains, Northwest Territories, Canada, specimen GSC 90169, transverse section, ×7 (Voronova & others, 1987); *b,* Maitlen Formation, Botoman, Colville, Washington, United States, holotype, GSC 14317, transverse section, ×7.5 (Greggs, 1959); *c,* Sekwi Formation, Botoman, Mackenzie Mountains, Northwest Territories, Canada, specimen GSC 90170, oblique transverse section, ×7.5 (Voronova & others, 1987).

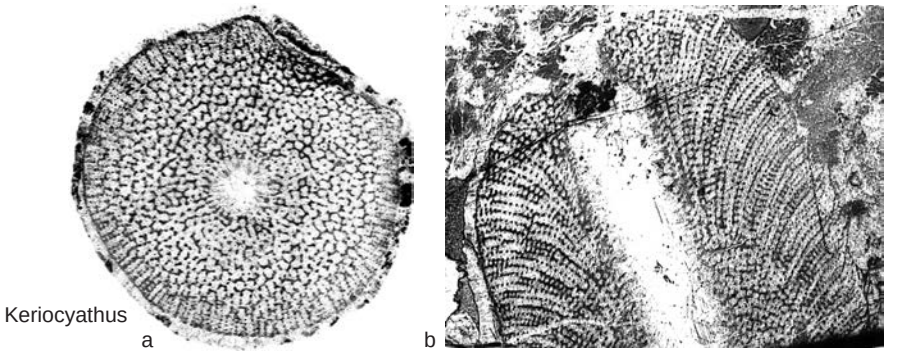


FIG. 648. Keriocyathidae (p. 1070).

Superfamily KRUSEICNEMOIDEA Debrenne & Zhuravlev, 1990

[*nom. correct.* DEBRENNE, ZHURAVLEV, & KRUSE, herein, *pro* Kruseicnemidoidea DEBRENNE & ZHURAVLEV, 1992b, p. 117, *nom. transl. ex* Kruseicnemididae DEBRENNE & ZHURAVLEV, 1990, p. 301]

Outer wall pustular. *lower Cambrian (Bot.3).*

FIG. 649. Gatagacyathidae (p. 1070–1071).

Family KRUSEICNEMIDAE Debrenne & Zhuravlev, 1990

[*nom. correct.* DEBRENNE, ZHURAVLEV, & KRUSE, herein, *pro* Kruseicnemididae DEBRENNE & ZHURAVLEV, 1990, p. 301]

Inner wall with bracts, fused bracts or pore tubes. *lower Cambrian (Bot.3).*

Kruseicnema DEBRENNE, GRAVESTOCK, & ZHURAVLEV in DEBRENNE & ZHURAVLEV, 1990, p. 301 [**Syringocnema gracilis* GORDON, 1920, p. 699; OD; holotype, GORDON, 1920, pl. 4,*43,46,* NHM S10412-10413, London]. Outer wall pustules bearing supplementary multiperforate tumuli; inner wall with one row of pores per syrinx, bearing upwardly projecting, S-shaped pore tubes; syringes hexagonal in cross section with several pore rows per facet. *lower Cambrian (Bot.3):* Australia, Antarctica, South Africa (allochthonous), Falkland Islands (allochthonous).——FIG. 655,*1a–b*. **K. gracilis* (GORDON), allochthonous, Botoman, Weddell Sea, Antarctica, holotype, NHM S10412-10413; *a,* oblique longitudinal section, ×9; *b,* transverse section, ×9 (Gordon, 1920).

Superfamily FRAGILICYATHOIDEA Belyaeva, 1975

[*nom. transl.* DEBRENNE & ZHURAVLEV, 1992b, p. 117, *ex* Fragilicyathidae BELYAEVA in BELYAEVA & others, 1975, p. 117]

Outer wall with canals. *lower Cambrian (Bot.1).*

Family FRAGILICYATHIDAE Belyaeva, 1975

[Fragilicyathidae BELYAEVA in BELYAEVA & others, 1975, p. 117]

Inner wall with bracts, fused bracts, or pore tubes. *lower Cambrian (Bot.1).*

FIG. 650. Auliscocyathidae (p. 1073).

Fragilicyathus BELYAEVA, 1969, p. 98 [**F. zhuravlevae*; OD; holotype, BELYAEVA, 1969, pl. 37,*7*, DVGU 6M/212/15-3, Khabarovsk]. Outer wall with horizontal to upwardly projecting, straight canals; inner wall with one row of pores per syrinx, bearing upwardly projecting, S-shaped pore tubes; syringes hexagonal in cross section with several pore rows per facet. *lower Cambrian (Bot.1):* Far East.——FIG. 655,*2. *F. zhuravlevae*, Ust'toka unit, Botoman, Gerbikan River, Dzhagdy Range, Far East, Russia, holotype, DVGU 6M/212/15-3, oblique longitudinal section, ×5.5 (Debrenne, Zhuravlev, & Kruse, 2002).

Order KAZACHSTANICYATHIDA Konyushkov, 1967

[Kazachstanicyathida KONYUSHKOV, 1967, p. 105]

Cup multichambered, solitary or modular, with massive modular types by individualization of modules around new central cavities; development of thalamid type, with stromatoporoid growth pattern; chambers of subspherical to laterally elongate shape, with pillars. *lower Cambrian (Bot.1–Bot.3).*

Suborder KAZACHSTANICYATHINA Konyushkov, 1967

[*nom. transl.* DEBRENNE & ZHURAVLEV, 1992b, p. 118, *ex* Kazachstanicyathida KONYUSHKOV, 1967, p. 105] [=Kazakhstanicyathida HILL, 1972, p. 130, *nom. null.*; =Korovinellina DEBRENNE, 1991, p. 219]

Initial chambers hollow and elongate; pillars developed in subsequent chambers; inner wall invaginal. *lower Cambrian (Bot.1–Bot.3).*

FIG. 651. Tuvacnemidae (p. 1073).

Family KOROVINELLIDAE Khalfina, 1960

[Korovinellidae KHALFINA, 1960a, p. 80] [=Kazachstanicyathidae KONYUSHKOV, 1967, p. 106; =Kazakhstanicyathidae HILL, 1972, p. 130, *nom.null.*]

Outer and inner walls with simple pores. *lower Cambrian (Bot.1–Bot.3).*

Korovinella RADUGIN in KHALFINA, 1960a, p. 80 [**Clathrodictyon sajanicum* YAVORSKY, 1932, p. 614; OD; holotype, YAVORSKY, 1932, fig. 4–5, M, TsNIGRm 4a,b/4070, St. Petersburg] [=*Kazachstanicyathus* KONYUSHKOV, 1967, p. 106 (type, *K. fistulatus,* OD); =*Kazakhstanicyathus* HILL, 1972, p. 130, *nom. null.*]. Outer and inner walls tabular; chambers of simple segmented tabulae and pillars. *lower Cambrian (Bot.3):* Altay Sayan, Kazakhstan.——FIG. 656,*1a–b*. **K. sajanica* (YAVORSKY), Verkhnemonok Formation, Botoman, Sanashtykgol Spring, West Sayan, Altay Sayan, Russia; *a,* oblique transverse section, topotype, PIN 4754/10, ×10 (Debrenne, Zhuravlev, & Kruse, 2002); *b,* holotype, TsNIGRm 4a,b/4070, transverse section of modular skeleton, ×10 (Yavorsky, 1932).

Bicoscinus DEBRENNE, 1977a, p. 127 [**B. sdzuyi*; OD; holotype, DEBRENNE, 1977a, pl. 14,*2*, MNHN M80058, specimen IRH13-1d, Paris]. Outer wall aporose (possibly rudimentary); inner wall simple; tabulae. *lower Cambrian (Bot.1):* Morocco.——FIG. 656,*2*. **B. sdzuyi*, Issafen Formation, Botoman, Jbel Irhoud, holotype, MNHN M80058, specimen IRH13-1d, oblique longitudinal section, ×5 (Debrenne, 1977a).

Suborder ALTAICYATHINA Debrenne, 1991

[Altaicyathina DEBRENNE, 1991, p. 219]

Initial chambers subspherical; pillars present in initial and subsequent chambers. *lower Cambrian (Bot.1–Bot.2).*

Family ALTAICYATHIDAE Debrenne & Zhuravlev, 1992

[Altaicyathidae DEBRENNE & ZHURAVLEV, 1992b, p. 118]

Outer and inner walls with simple pores. *lower Cambrian (Bot.1–Bot.2).*

Altaicyathus VOLOGDIN, 1932, p. 26 [**A. notabilis*; M; lectotype, VOLOGDIN, 1932, pl. 1,*5;* SD DEBRENNE & ZHURAVLEV, 1992b, p. 48, TsNIGRm 290/2957, St. Petersburg] [=*Praeactinostroma* KHALFINA, 1960a, p. 81 (type, *Actinostroma vologdini* YAVORSKY, 1932, p. 613, OD); =*Cambrostroma* VLASOV, 1961, p. 29 (type, *C. rossicum*, OD); =*Abakanicyathus* KONYUSHKOV in ZHURAVLEVA, KONYUSHKOV, & ROZANOV, 1964, p. 127 (type, *A. karakolensis*, OD), for discussion, see DEBRENNE & ZHURAVLEV, 1992b, p. 119; =*Altaicyathus notabilis* VOLOGDIN, 1932, p. 26)]. Outer and inner walls tabular; chambers of simple segmented tabulae and pillars; exaules and astrorhizae may be present. *lower Cambrian (Bot.1–Bot.2):* Altay Sayan, Mongolia, Far East, United States.——FIG. 657. **A. notabilis*, Verkhneynyrga Formation, Botoman, Lebed' River, Altay Mountains, Altay Sayan, Russia, lectotype, TsNIGRm 290/2957, longitudinal section, ×9 (Vologdin, 1932).

NOMINA DUBIA

Adaecyathus FONIN in ZHURAVLEV, ZHURAVLEVA, & FONIN, 1983, p. 28 (FONIN in KRASNOPEEVA, 1978, p. 81, *nom. nud.*) [**A. gravis*; OD].

Araneocyathus VOLOGDIN in SIMON, 1941, p. 5 (VOLOGDIN, 1937b, p. 466, *nom. nud.*) [**A. curvus* VOLOGDIN, 1940a, p. 64; SD SIMON, 1941, p. 5].

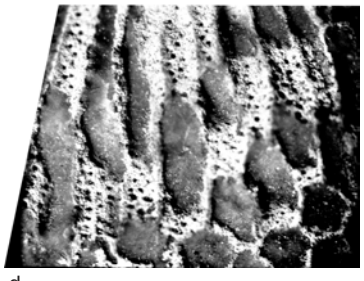
Archaeocyathellus FORD, 1873b, p. 135 [**Archaeocyathus? rensselaericus* FORD, 1873a, p. 211; M].

ARCHAEOCYATHOSPONGIA VOLOGDIN, 1940a, p. 27 (class).

Archaeofungiella ZHURAVLEVA in ZHAUTIKOV & others, 1976, p. 137 [**A. chingisiensis*; OD].

a

c



d

Syringocnema

b

FIG. 652. Syringocnemidae (p. 1073–1074).

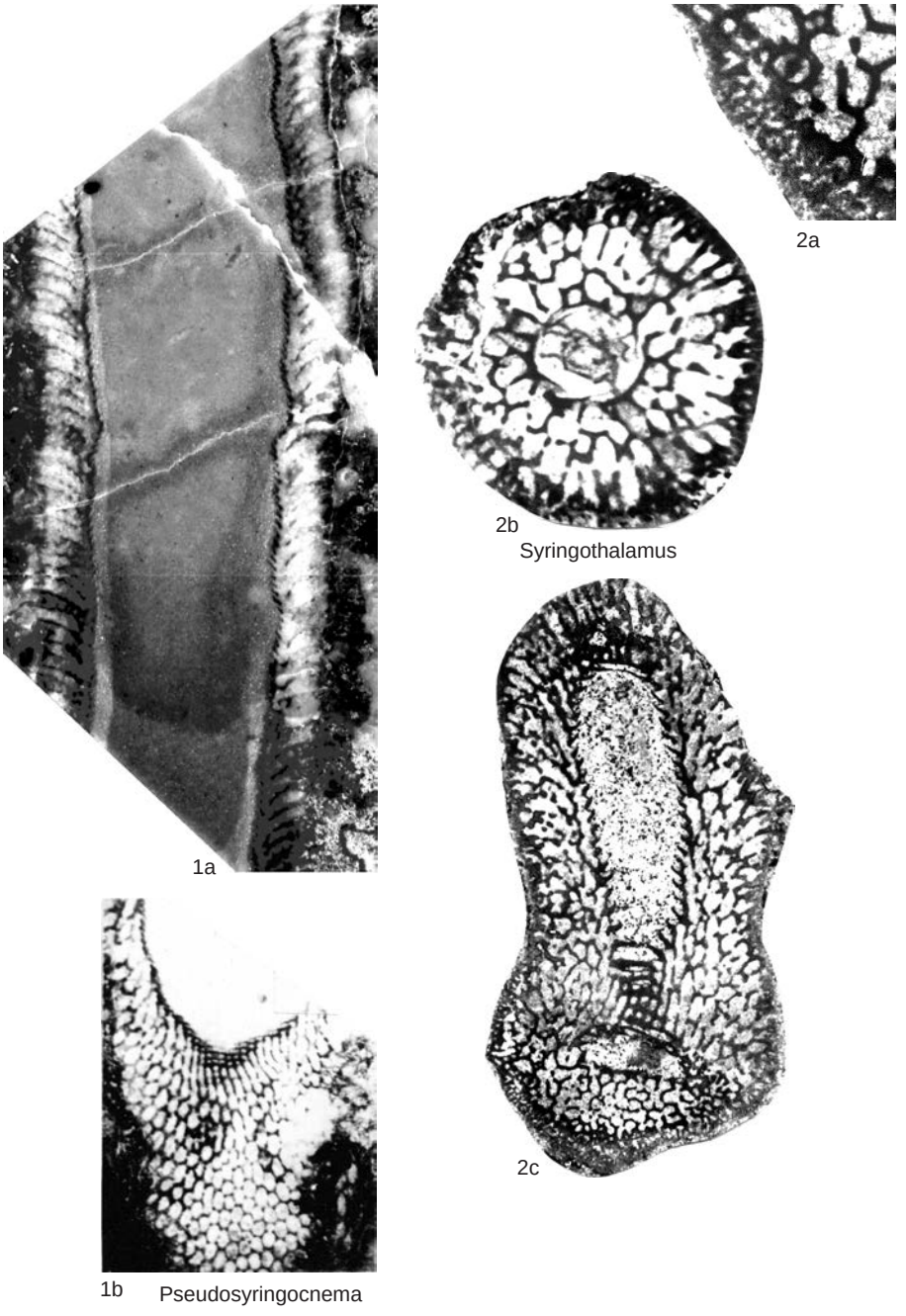


FIG. 653. Syringocnemidae (p. 1074).

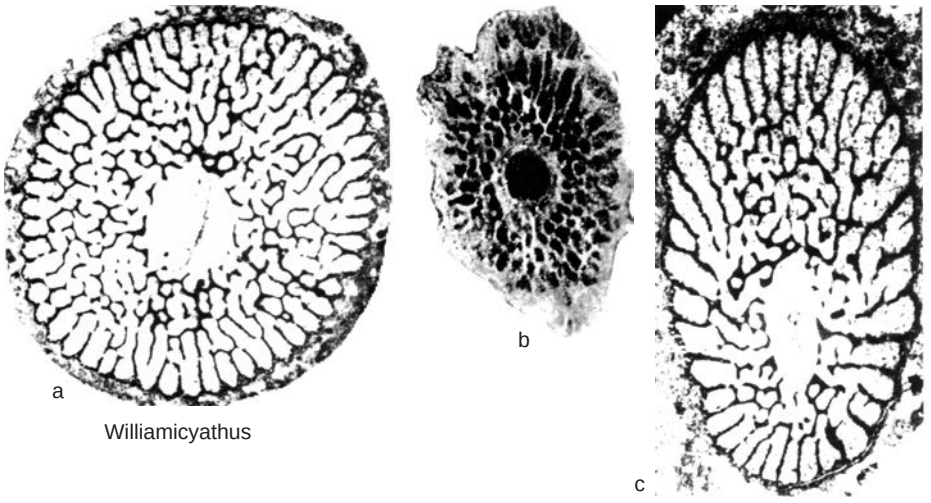


FIG. 654. Syringocnemidae (p. 1075).

ARCHAEOPHYLLIDA OKULITCH, 1943, p. 46, *nom. correct*. OKULITCH, 1955a, p. 10, *pro* order Archaeophyllina OKULITCH, 1943, p. 46.

ARCHAEOPHYLLIDAE VOLOGDIN, 1940b, p. 97 [=Archaeophyllidae VOLOGDIN, 1931, p. 60, *nom. nud.*].

Archaeophyllum VOLOGDIN in SIMON, 1939, p. 21 (VOLOGDIN, 1931, p. 61, *nom. nud.*) [**A. edelsteini* VOLOGDIN, 1931, p. 62; SD SIMON, 1939, p. 21].

BACATOCYATHIDAE ZHURAVLEVA, 1960b, p. 268, *nom. correct*. HILL, 1965, p. 116, *pro* Batchatocyathidae ZHURAVLEVA, 1960b, p. 268.

Bacatocyathus VOLOGDIN, 1940b, p. 95, *nom. correct*. HILL, 1965, p. 116, *pro Bačatocyathus* VOLOGDIN, 1940b, p. 95 [**B. kazakevici*; OD] [=*Batschatocyathus* VOLOGDIN, 1956, p. 878, *nom. null.*; =*Batchatocyathus* ZHURAVLEVA, 1960b, p. 268, *nom. null.*].

Beticocyathus SIMON, 1939, p. 73 [**B. beticus*; OD].

BICYATHIDAE VOLOGDIN, 1937b, p. 472.

Bicyathus VOLOGDIN, 1939, p. 235 (VOLOGDIN, 1937b, p. 472, *nom. nud.*) [**B. angustus*; OD].

Butovia VOLOGDIN, 1931, p. 63 [**B. serrata*; M].

CROMMYOCYATHINA R. BEDFORD & J. BEDFORD, 1939, p. 79 (order).

Dendrocyathus OKULITCH & ROOTS, 1947, p. 44 [**D. unexpectans*; M].

Echinocyathus H. TERMIER & G. TERMIER, 1950, p. 47 [**E. goundafensis*; OD] [=*Dictyocyathus (Echinocyathus)* H. TERMIER & G. TERMIER, 1950, p. 47, *nom. transl*. DEBRENNE, 1964, p. 207, *ex Echinocyathus* H. TERMIER & G. TERMIER, 1950, p. 47].

Echinocyathus VOLOGDIN, 1960, p. 424, *non* H. TERMIER & G. TERMIER, 1950, p. 47 (type, *E. goundafensis,* OD) [**E. bilateralis*; OD].

ETHMOLYNTHIDAE ZHURAVLEVA, 1963b, p. 112, *nom. transl*. HILL, 1972, p. 51, *ex* Ethmolynthinae ZHURAVLEVA, 1963b, p. 112.

Ethmolynthus ZHURAVLEVA, 1963b, p. 112 [**E. rosanovi*; OD].

EXOCYATHA OKULITCH, 1943, p. 42 (subclass).

EXOCYATHIDAE R. BEDFORD & J. BEDFORD, 1939, p. 82.

Exocyathus R. BEDFORD & J. BEDFORD, 1937, p. 32 [**E. australis*; OD].

Gorskinocyathus VOLOGDIN, 1960, p. 422 [**Archaeocyathus gorskinensis* VOLOGDIN, 1940b, p. 60; OD].

Kameschkovia VOLOGDIN, 1957a, p. 183 (VOLOGDIN, 1956, p. 880, *nom. nud.*) [**Labyrinthomorpha perforata* VOLOGDIN, 1940b, p. 40; M].

LABYRINTHOCYATHIDAE YAROSHEVICH, 1962, p. 117.

Labyrinthocyathus YAROSHEVICH, 1962, p. 117 [**L. grandiporosus*; M].

Labyrinthomorpha VOLOGDIN, 1931, p. 35 [**L. tolli*; M] [=*Labirinthomorpha* VOLOGDIN, 1928, p. 32, *nom. nud.*].

LABYRINTHOMORPHIDA VOLOGDIN, 1961, p. 180 (order).

LABYRINTHOMORPHIDAE VOLOGDIN, 1962a, p. 125 [=Labirinthomorphidae VOLOGDIN, 1928, p. 32, *nom. nud.*].

LABYRINTHOMORPHINA VOLOGDIN, 1961, p. 180 (superorder), *nom. transl.* VOLOGDIN, 1962a, p. 125, *ex* order Labyrinthomorphida VOLOGDIN, 1961, p. 180].

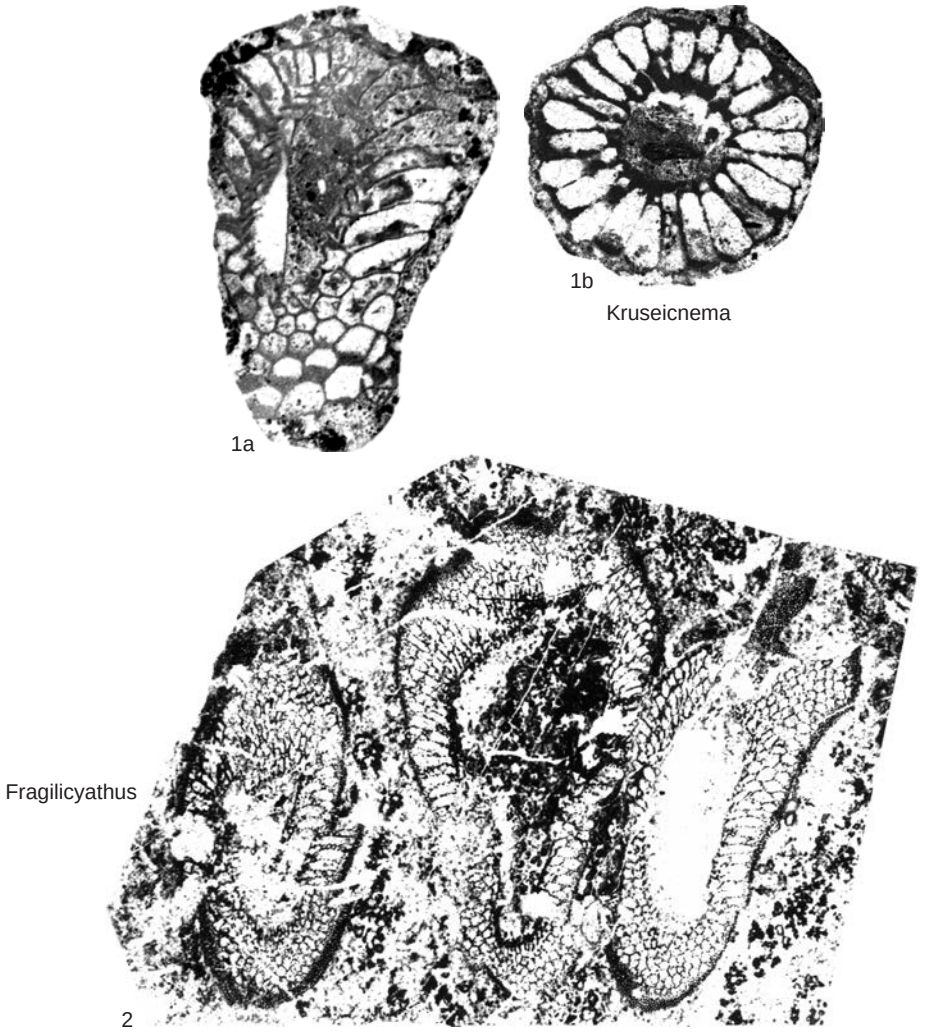


FIG. 655. Kruseicnemidae and Fragilicyathidae (p. 1076–1077).

LEECYATHIDAE VOLOGDIN, 1957c, p. 495 [=Leecyathidae VOLOGDIN, 1956, p. 879, *nom. nud.*].
Leecyathus VOLOGDIN, 1957c, p. 495 [**Archaeocyathus yavorskii* VOLOGDIN, 1931, p. 86; OD] [=*Zeecyathus* VOLOGDIN, 1956, p. 879, *nom. nud., lapsus calami pro Leecyathus*].
Leiocyathus VOLOGDIN, 1959a, p. 671 [**L. inaequitaenialis*; OD].
Nevadacyathus OKULITCH, 1943, p. 59 [**Archaeocyathus septaporus* OKULITCH, 1935b, p. 101; M].
Pinacocyathus R. BEDFORD & W. R. BEDFORD, 1934, p. 4 [**P. spicularis*; M].
Potekhinocyathus VOLOGDIN, 1957d, p. 699 [**P. bateniensis*; M].
Protocyclocyathus VOLOGDIN, 1955, p. 142 [**Cyclocyathus irregularis* VOLOGDIN, 1940b, p. 62; M].
RHIZACYATHIDAE R. BEDFORD & J. BEDFORD, 1939, p. 69.
Rhizacyathus R. BEDFORD & J. BEDFORD, 1939, p. 69 [**Protopharetra radix* R. BEDFORD & J. BEDFORD, 1937, p. 28; OD].
Salopicyathus VOLOGDIN, 1962c, p. 86 [**S. complanatoporosus*; OD].
Septocyathus VOLOGDIN, 1937b, p. 468 [**S. pedaschenkoi*; M].
Serligocyathus VOLOGDIN, 1959a, p. 671 [**S. lukashevi*; OD].
SOMPHOCYATHIDAE OKULITCH, 1935b, p. 98.

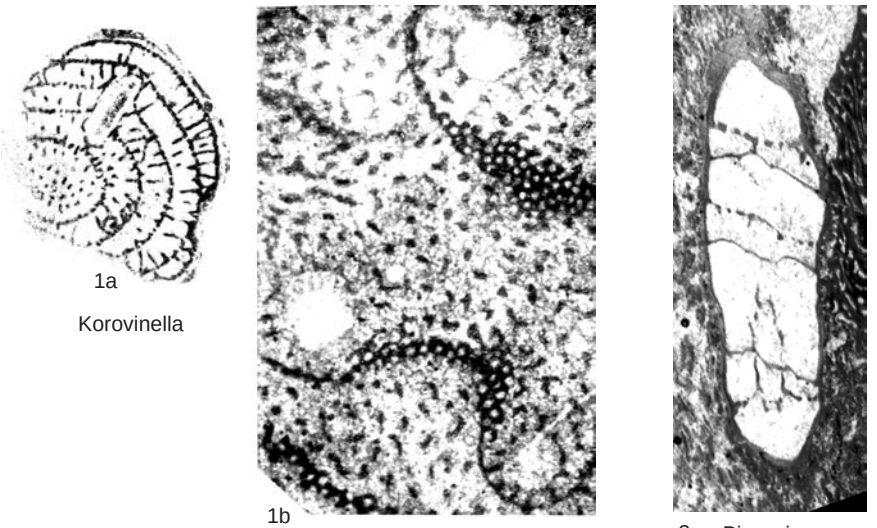


FIG. 656. Korovinellidae (p. 1078).

Somphocyathus TAYLOR, 1910, p. 134 [**S. coralloides*; M].

Sphinctocyathus (Sphinctocyathus) ZHURAVLEVA, 1960b, p. 304 [**S. (S.) oimuranicus*; OD].

Squamella VOLOGDIN, 1977, p. 75, *non* BORY DE SAINT-VINCENT, 1826, p. 90 (type, *S. limulina,* M), rotifer [**S. prima*; OD] [=*Squamellicyathus* VOLOGDIN, 1977, p. 22, *nom. nud.*].

TABULACYATHIDA VOLOGDIN, 1956, p. 878 (order), *nom. correct.* HILL, 1972, p. 121 *pro* Tabulocyathida VOLOGDIN, 1956, p. 878, *lapsus calami.*

TABULACYATHIDAE VOLOGDIN, 1956, p. 878, *nom. correct.* HILL, 1972, p. 123, *pro* Tabulathyathidae VOLOGDIN in REPINA & others, 1964, p. 249, *nom. correct. pro* Tabulocyathidae VOLOGDIN, 1956, p. 878, *lapsus calami.*

Tabulacyathus VOLOGDIN, 1932, p. 30 [**T. taylori;* M] [=*Tabulocyathus* VOLOGDIN, 1937b, p. 471, *nom. null.*].

TABULOIDEA VOLOGDIN, 1957a, p. 183 (class).

TANNUOLACYATHIDAE DEBRENNE, 1964, p. 188.

Tannuolacyathus VOLOGDIN, 1957c, p. 496 [**T. multiplex;* OD].

TEREKTIGOCYATHIDAE VOLOGDIN, 1962b, p. 419.

Terektigocyathus VOLOGDIN, 1962b, p. 420 [**T. primus*; OD].

Tersia VOLOGDIN, 1931, p. 70 [**T. filiforma*; M].

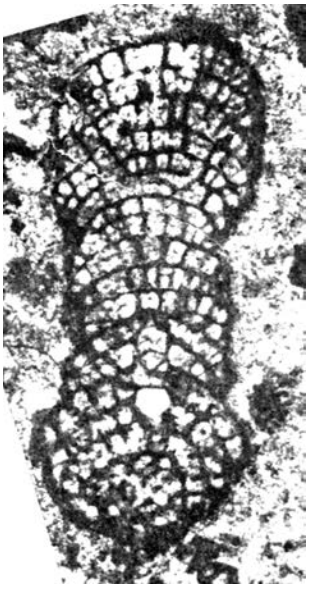


FIG. 657. Altaicyathidae (p. 1078).

Tersiella VOLOGDIN, 1962a, p. 129 [**Tersia nodosa* VOLOGDIN, 1940a, p. 34; OD].

THALASSOCYATHIDAE VOLOGDIN, 1962a, p. 116.

Thalassocyathus VOLOGDIN, 1957d, p. 699 [**T. acutatus*; M].

Torgaschinocyathus VOLOGDIN, 1957d, p. 699 [**T. spinosus*; M].

Turgidocyathus VOLOGDIN, 1960, p. 422 [**T. ippolitovensis*; OD].

Tuvacyathus VOLOGDIN, 1940a, p. 112 (VOLOGDIN, 1937b, p. 471, *nom. nud.*) [**T. mollimurus*; M].

URALOCYATHIDAE VOLOGDIN & ZHURAVLEVA in VOLOGDIN, 1956, p. 878 [=Vacuocyathidae VOLOGDIN, 1962c, p. 77].

Vacuocyathus OKULITCH, 1950a, p. 392, *nom. nov. pro Coelocyathus* VOLOGDIN, 1939, p. 237, *non* SARS, 1857, p. 126, cnidarian, *nec* SCHLÜTER, 1886, p. 899, cnidarian [**Coelocyathus kidrjassovensis* VOLOGDIN, 1939, p. 237; OD; =*Coelocyathus kidrjassovensis* VOLOGDIN, 1937b, p. 478, *nom. nud.*] [=*Uralocyathus* ZHURAVLEVA, 1960b, p. 102 (type, *Coelocyathus kidrjassovensis* VOLOGDIN, 1939, p. 237, OD), *nom. nov. pro Coelocyathus* VOLOGDIN, 1939, p. 237, archaeocyath].

VESICULOIDA VOLOGDIN, 1956, p. 878 (order).

VESICULOIDAE VOLOGDIN, 1931, p. 34, invalid family-group name based on unavailable genus name.

NOTE ADDED IN PROOF

A publication by SKORLOTOVA (2013) could not be included in the present volume. Among other new archaeocyath taxa, the paper describes the following new genera: *Turgorocyathus* SKORLOTOVA, 2013, p. 4 (type, *T. elegans;* OD) in Ajacicyathidae; *Angustocyathus* SKORLOTOVA, 2013, p. 5 (type, *A. porus;* OD) in Densocyathidae; and *Flossocyathus* SKORLOTOVA, 2013, p. 6 (type, *F. squamosus;* OD) in Coscinocyathidae. All are from the *Carinacyathus pinus* Zone (Atd.2), Lena River, Sakha (Yakutia), Russia. Type material is lodged in the Paleontologicheskiy Institut RAN, Moscow, as PIN 5499.

RADIOCYATHS AND POTENTIALLY ALLIED TAXA: SYSTEMATIC DESCRIPTIONS

P. D. Kruse, A. Yu. Zhuravlev, and F. Debrenne

Radiocyaths show superficial similarity to archaeocyaths in size, shape, and gross morphology, and typically co-occur with them. They were first described from the lower Cambrian of South Australia as *Heterocyathus* R. Bedford & W. R. Bedford, 1934, a preoccupied name later substituted with *Radiocyathus* Okulitch, 1937a. This latter was to become the eponymous genus for the entire group (Debrenne, H. Termier, & G. Termier, 1970).

Radiocyath skeletons may range up to 20 cm in height and 12 cm in diameter, although the majority are around 2–5 cm diameter. Apart from some branching *Girphanovella* Zhuravleva and *Gonamispongia* Korshunov, they are solitary. The skeleton may be globular, conical, or pyriform, composed of one or two walls, the walls in the latter being linked by radial rods, thus superficially resembling certain species of the archaeocyath *Dokidocyathus* Taylor. Nevertheless, radiocyaths differ fundamentally from archaeocyaths in that their walls are constructed of more or less uniformly arranged nesasters (Debrenne, H. Termier, & G. Termier, 1971): solid starlike structures consisting of 6–20 coplanar rays radiating from a central boss. Walls range from those apparently composed of relatively isolated nesasters, as in the poorly preserved *Kuraya* Romanenko (treated herein as a probable synonym of *Uranosphaera* R. Bedford & W. R. Bedford), to those constructed of nesasters whose rays are intricately linked to form a continuous skeletal network, as in *Radiocyathus* Okulitch and *Girphanovella* Zhuravleva. Nesasters may be two layered, as, for example, in *Radiocyathus* Okulitch, in which nesasters have an internal layer of radial rays that fuse with rays of adjacent nesasters at angled junctions, and an external layer of anastomosing rays and tangential linking cross pieces that constitute a microporous sheath (Debrenne, H. Termier, & G. Termier, 1970; Kruse, 1991).

The lower end of the skeleton appears to have been closed. The upper end is not commonly preserved, and a distal opening is confirmed only in *Uranosphaera* R. Bedford & W. R. Bedford, which bears a circular opening about one third the equatorial skeleton diameter. Skeletal growth was from the lower end, with intermingling of differently sized nesasters in some taxa implying that additional nesasters may have been subsequently inserted interstitially (Zhuravlev, 1986b). Alternatively, the organism may simply have exerted little control over nesaster size at the growing edge, with resultant size variation.

Historically, most studied specimens have been secondarily silicified, dolomitized, or phosphatized. The microstructure of unaltered specimens is typically a mosaic of equant calcite spar, suggestive of an original aragonitic skeletal mineralogy based on the comparative approach of James and Klappa (1983). Exceptionally, Zhuravlev (1986b) reported what may be an original microstructure: a fabric of interlocking isometric microgranules 3–6 μm in size,

although this may represent contamination due to intergrowth with archaeocyaths.

Neither the rank of radiocyathan suprageneric taxa nor the placement of genera within family-rank taxa is universally agreed. ZHURAVLEV and SAYUTINA (1985), in their restudy of *Kuraya* ROMANENKO (?=*Uranosphaera* R. BEDFORD & W. R. BEDFORD) and *Gonamispongia* KORSHUNOV, suggested that one-walled forms are merely incompletely mineralized or preserved two-walled forms. These authors placed *Gonamispongia* KORSHUNOV in their two-walled Radiocyathinae (Hetairacyathidae, herein), as it has rods projecting radially inward from its wall nesasters; they further amalgamated Girphanovellidae with Radiocyathidae (as Radiocyathinae). ZHURAVLEVA and MYAGKOVA (1987) assigned *Gonamispongia* KORSHUNOV to a separate subfamily.

The class has been allied variously with spiculate (especially heteractinide) sponges or archaeocyaths (R. BEDFORD & W. R. BEDFORD, 1934; OKULITCH, 1935b, 1955a; R. BEDFORD & J. BEDFORD, 1937; ROZANOV in ZHURAVLEVA, KONYUSHKOV, & ROZANOV, 1964; ZHURAVLEVA in ZHURAVLEVA, ZADOROZHNAYA, & others, 1967; KORSHUNOV, 1968; ROMANENKO, 1968; ROZANOV & ZHURAVLEV, 1992; FINKS & RIGBY, 2004a), or considered as a problematic class of uncertain affinity (HILL, 1965, 1972). RIGBY and NITECKI (1975), erroneously believing the nesasters to be sutured, claimed for *Uranosphaera* R. BEDFORD & W. R. BEDFORD a close relationship to chancelloriids. These latter are now recognized as a group of nonporiferan epithelium-bearing metazoans (MEHL, 1996; BENGTSON & HOU, 2001; JANUSSEN, STEINER, & ZHU, 2002).

More recent studies have related the class most closely to the Early Ordovician–Permian receptaculitaleans, a group popularly allied with calcareous algae (NITECKI, 1972; CAMPBELL, HOLLOWAY, & SMITH, 1974; RIETSCHEL, 1977; NITECKI & DEBRENNE, 1979; BEADLE, 1988), though most recently regarded as problematic (neither sponges, nor dasycladalean algae) by NITECKI and MUTVEI (1996) and M. H. NITECKI, MUTVEI, and D. V. NITECKI (1999). In the receptaculitalean model, homology is drawn between the receptaculitalean merom (consisting of shaft, inner platelike foot and outer quadribrachial structure with surmounting head plate) and the radiocyathan radial rod connecting corresponding inner and outer nesasters (NITECKI & DEBRENNE, 1979; NITECKI & TOOMEY, 1979; MYAGKOVA, 1985; ZHURAVLEV & SAYUTINA, 1985; ZHURAVLEV, 1986b). This proposed affinity with receptaculitaleans is consistent with microstructural (KRUSE & DEBRENNE, 1989) and mineralogical comparisons (DZIK, 1994; NITECKI & MUTVEI, 1996). Nevertheless, because the possibility of a poriferan affinity remains, the Radiocyatha are included in the present *Treatise* revision.

A dissenting view of phylogenetic relationships was advanced by ZHURAVLEVA and MYAGKOVA (1987). These authors grouped radiocyaths together with heteractinide sponges, chancelloriids, and some receptaculitaleans in a phylum, Receptaculita, itself grouped with the phylum Archaeocyatha, as the subkingdom Archaeata in the kingdom Inferibionta. The Archaeata-Inferibionta concept has not found favor with other researchers.

Radiocyaths appeared on the Siberian Platform in the late Tommotian, spread into adjacent Altay Sayan, Tuva, Mongolia, and Transbaikalia in the early Atdabanian and had reached Morocco, Australia, Antarctica, and Laurentia by the Botoman. As with archaeocyaths, their range contracted thereafter; the latest radiocyaths are from the middle Toyonian of South Australia.

Limited paleoecological studies indicate that at least some radiocyaths were reef

dwellers or constructors. They contributed to reefs in the Tommotian of the Siberian Platform, Atdabanian of Mongolia and central Australia, and Toyonian of South Australia (KENNARD, 1991; KRUSE, 1991; WOOD, ZHURAVLEV, & CHIMED TSEREN, 1993; KRUSE, ZHURAVLEV, & JAMES, 1995; KRUSE & others, 1996).

?Class RADIOCYATHA Debrenne, H. Termier, & G. Termier, 1970

[Radiocyatha DEBRENNE, H. TERMIER, & G. TERMIER, 1970, p. 120] [=order Hetairacyathida R. BEDFORD & J. BEDFORD, 1937, p. 27, *nom. correct.* OKULITCH, 1955a, p. 18, *pro* order Hetairacyathina R. BEDFORD & J. BEDFORD, 1937, p. 27, *nom. nov. pro* order Heterocyathina OKULITCH, 1935b, p. 90, based on junior homonym; =order Uranosphaerina R. BEDFORD & J. BEDFORD, 1939, p. 82; =subclass Uranocyatha OKULITCH, 1943, p. 42; =order Radiocyatales DEBRENNE, H. TERMIER, & G. TERMIER, 1970, p. 120, *nom. transl.* NITECKI & TOOMEY, 1979, p. 728, *ex* class Radiocyatha DEBRENNE, H. TERMIER, & G. TERMIER, 1970, p. 120; =Radiocyathaceae OKULITCH, 1955a, p. 18, *nom. transl.* ZHURAVLEV & SAYUTINA, 1985, p. 54, *ex* Radiocyathidae OKULITCH, 1955a, p. 18; =order Radiocyathida ZHURAVLEVA & MYAGKOVA, 1987, p. 73]

One- or two-walled globular, conical, or pyriform skeletons constructed of nesasters; corresponding nesasters of inner and outer wall linked by radial rods, which may bifurcate toward outer wall, in two-walled forms; rods project radially inward from wall of some one-walled forms; original skeletal mineralogy aragonitic. [The rank of Radiocyatha is uncertain (DEBRENNE, H. TERMIER, & G. TERMIER, 1970).] *lower Cambrian (Tom.3–Toy.2).*

Family HETAIRACYATHIDAE R. Bedford & J. Bedford, 1937

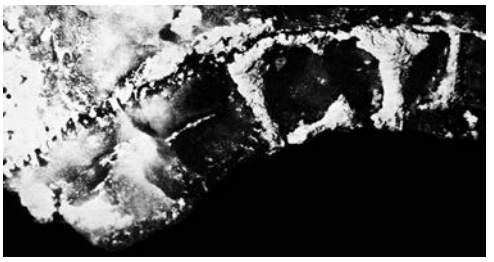
[Hetairacyathidae R. BEDFORD & J. BEDFORD, 1937, p. 27, *nom. nov. pro* Heterocyathidae R. BEDFORD & W. R. BEDFORD, 1934, p. 6, based on junior homonym] [=Radiocyathidae OKULITCH, 1955a, p. 18; =Girphanovellidae DEBRENNE, H. TERMIER, & G. TERMIER, 1971, p. 442; =Kazakovicyathidae KONYUSHKOV, 1972, p. 130; =family Radiocyataceae OKULITCH, 1955a, p. 18, *nom. correct.* NITECKI & TOOMEY, 1979, p. 728, *pro* Radiocyathidae OKULITCH, 1955a, p. 18; =family Girvanovellaceae DEBRENNE, H. TERMIER, & G. TERMIER, 1971, p. 442, *lapsus calami pro* Girphanovellaceae, *nom. correct.* NITECKI & TOOMEY, 1979, p. 728, *pro* Girphanovellidae DEBRENNE, H. TERMIER, & G. TERMIER, 1971, p. 442; =Radiocyathaceae ZHURAVLEV & SAYUTINA, 1985, p. 54, *nom. transl. et correct. ex* Radiocyathidae OKULITCH, 1955a, p. 18; =Radiocyathinae OKULITCH, 1955a, p. 18, *nom. transl.* ZHURAVLEV & SAYUTINA, 1985, p. 54, *ex* Radiocyathidae OKULITCH, 1955a, p. 18; =Gonamispongiinae ZHURAVLEVA in ZHURAVLEVA & MYAGKOVA, 1987, p. 74]

Cup two-walled. *lower Cambrian (Tom.3–Toy.2).*

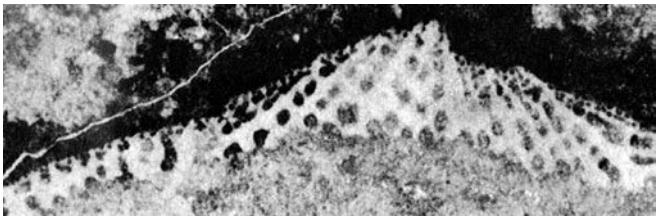
Radiocyathus OKULITCH, 1937a (April), p. 252, *nom. nov. pro Heterocyathus* R. BEDFORD & W. R. BEDFORD, 1934, p. 7 (type, *H. minor*, SD R. BEDFORD & W. R. BEDFORD, 1936, p. 20), *non* MILNE-EDWARDS & HAIME, 1848, p. 323 (type, *H. aequicostatus*, SD MILNE-EDWARDS & HAIME, 1850–1854, p. xv), cnidarian [**Heterocyathus minor* R. BEDFORD & W. R. BEDFORD, 1934, p. 7; SD R. BEDFORD & W. R. BEDFORD, 1936, p. 20; holotype, R. BEDFORD & W. R. BEDFORD, 1934, fig. 32; HILL, 1965, pl. 12,*4;* DEBRENNE, H. TERMIER, & G. TERMIER, 1970, pl. 4,*1-3,* pl. 5,*1;* M, S4196, NHM, London and PU87211, USNM, Washington, D.C.] [=*Hetairacyathus* R. BEDFORD & J. BEDFORD, 1937 (September), p. 27, *nom. nov. pro Heterocyathus* R. BEDFORD & W. R. BEDFORD, 1934, p. 7 (type, *H. minor*, SD R. BEDFORD & W. R. BEDFORD, 1936, p. 20), *non* MILNE-EDWARDS & HAIME, 1848, p. 323 (type, *H. aequicostatus,* SD MILNE-EDWARDS & HAIME, 1850–1854, p. xv), cnidarian]. Cup conical to pyriform, nesasters linked, of constant size and number of rays; outer wall with microporous sheath. *lower Cambrian (Atd.4–Bot.3)*: Australia, Antarctica, Falkland Islands (allochthonous).——FIG. 658,*1a–d*. **R. minor* (R. BEDFORD & W. R. BEDFORD); *a–c,* Ajax Limestone, Botoman, Ajax Mine, South Australia, Australia; *a–b,* holotype, USNM PU87211; *a,* transverse view, ×3; *b,* tangential view of outer wall (at left) and inner wall (at right), ×3; *c,* holotype, NHM S4196, tangential view of outer wall (at bottom) and inner wall (at top), ×3 (Debrenne, H. Termier, & G. Termier, 1970); *d,* Wilkawillina Limestone, Botoman, Wirrealpa Mine, South Australia, Australia, specimen SAM P47956, tangential section of outer wall, ×9 (Kruse, 1991).

Blastasteria DEBRENNE, H. TERMIER, & G. TERMIER, 1971, p. 442 [**B. bedfordorum*; OD; holotype, R. BEDFORD & W. R. BEDFORD, 1936, fig. 39; M; P922/3, SAM, Adelaide; =*Uranosphaera hexaster* R. BEDFORD & W. R. BEDFORD, 1936, p. 10, *non* R. BEDFORD & W. R. BEDFORD, 1934, p. 7]. Cup globular, nesasters independent. *lower Cambrian (Bot.3)*: Australia.——FIG.658,*2a–b*. **B. bedfordorum*, Ajax Limestone, Botoman, Ajax Mine, South Australia, Australia, holotype, SAM P922/3; *a,* sketch of transverse view, ×3; *b,* sketch of outer wall in tangential view, ×6 (R. Bedford & W. R. Bedford, 1936).

Girphanovella ZHURAVLEVA in ZHURAVLEVA, ZADOROZHNAYA, & others, 1967, p. 107 [**G. girphanovae*; OD; holotype, ZHURAVLEVA, ZADOROZHNAYA, & others, 1967, pl. 59,*1–2*, 325, TsSGM, Novosibirsk; =*Archaeocyathus neoproskurjakovi* VOLOGDIN, 1940b, p. 56, holotype not designated, collection not located; =Dokidocyathina? *georgensis* ROZANOV in ZHURAVLEVA, KONYUSHKOV, & ROZANOV, 1964, p. 100, holotype, ZHURAVLEVA, KONYUSHKOV, & ROZANOV, 1964, pl. 16,*8*, GIN3461, PIN, Moscow] [=*Kazakovicyathus* KONYUSHKOV, 1972, p. 130 (type, *K. sajanicus,* OD)]. Cup conical to pyriform, nesasters linked, of variable size



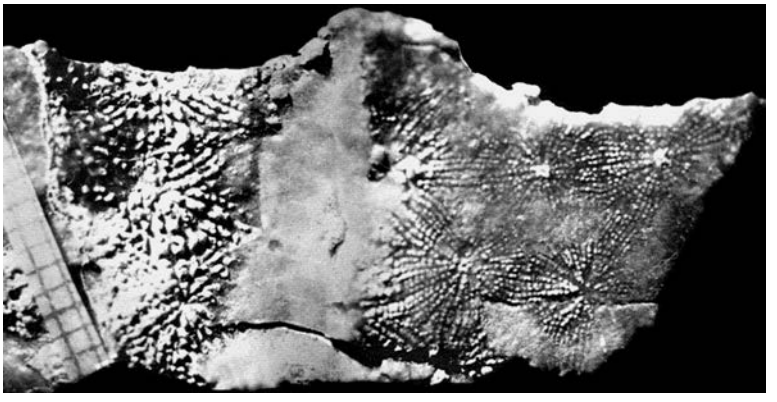
1a



1d

Radiocyathus

1c



1b

2a

2b

Blastasteria

FIG. 658. Hetairacyathidae (p. 1087).

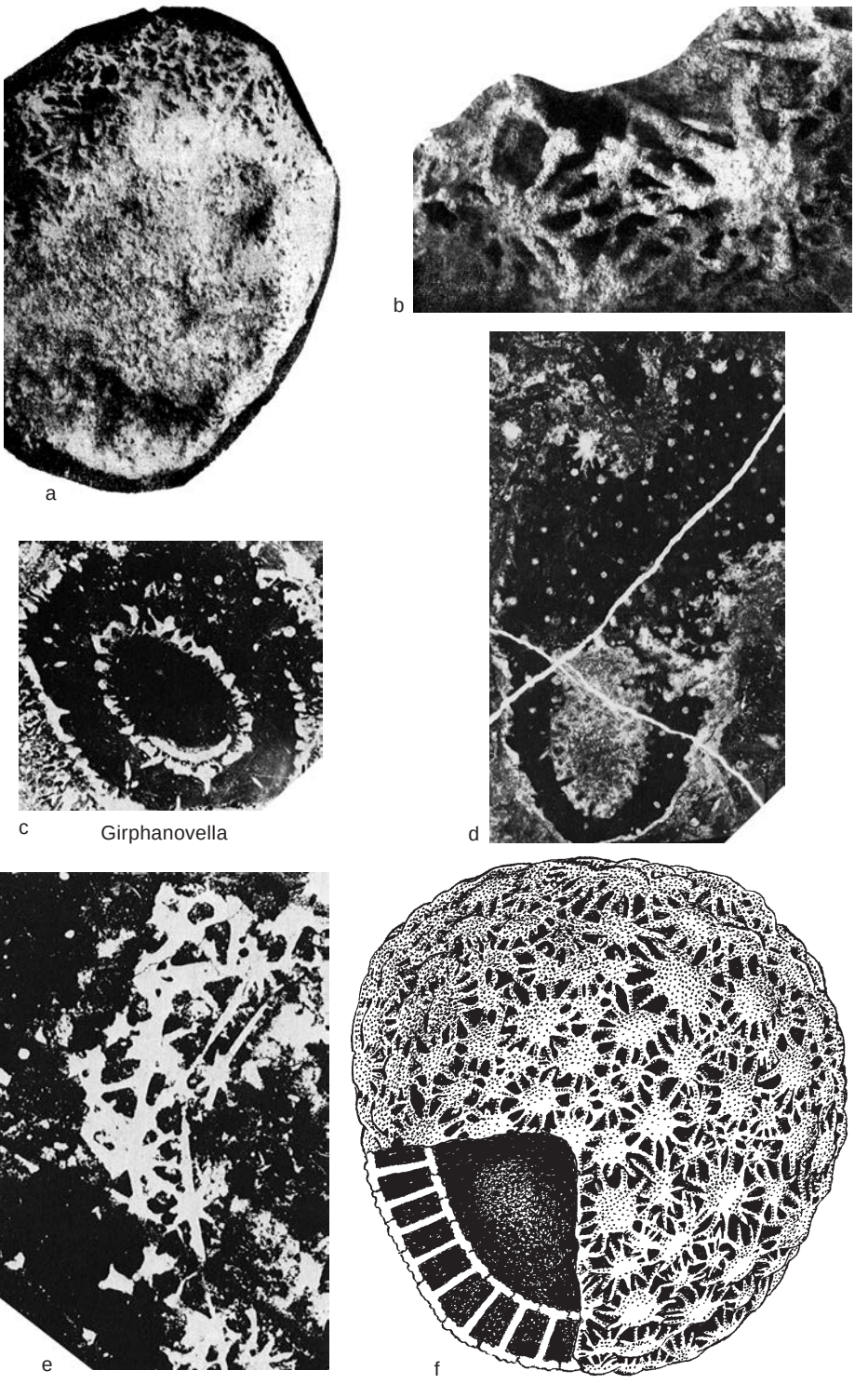


FIG. 659. Hetairacyathidae (p. 1087–1090).

and number of rays; outer wall with possible microporous sheath. *lower Cambrian (Atd.1–Toy.2)*: Siberian Platform, Altay Sayan, Tuva, Mongolia, Transbaikalia, Australia, ?Morocco, Canada.——Fig. 659*a–f. G. neoproskurjakovi* (Vologdin); *a–b,* = *G. girphanovae* Zhuravleva, Shangan Formation, Botoman, Shivelig-Khem River, Eastern Tannu-Ola Range, Tuva, Russia, holotype TsSGM 325; *a,* external view, ×1.8; *b,* tangential view of outer wall, ×10 (Zhuravleva, Zadorozhnaya & others, 1967); *c–e,* = *G. georgensis* (Rozanov); *c,* Bystraya Formation, Atdabanian, Georgievka, Argun' River, Transbaikalia, Russia, specimen PIN 3900/35, oblique transverse section, ×3; *d–e,* Salaany Gol Formation, Atdabanian, Mount Zuune Arts, Tsagaan Oloom province, Mongolia; *d,* specimen PIN 3482/51, oblique longitudinal section, ×3; *e,* specimen PIN 3482/53, tangential section of inner wall, ×6 (Zhuravlev, 1986b); *f,* Shangan Formation, Shivelig-Khem River, Eastern Tannu-Ola Range, Tuva, Russia, reconstruction based on etched specimens, external longitudinal view, ×1.5 (Kruse, Zhuravlev, & Debrenne, 2012).

Gonamispongia Korshunov, 1968, p. 127 [**G. ignorabilis*; OD; holotype, Korshunov, 1968, fig. 1a–v, 84/3, YaFAN, Yakutsk]. Cup conical to pyriform, nesasters linked, of constant size and number of rays; rods extend radially inward from nesaster centers. *lower Cambrian (Tom.3–Atd.1)*: Siberian Platform.——Fig. 660,*1a–b*. **G. ignorabilis*, Pestrotsvet Formation, Tommotian, Knyaz'-Yurakh Creek, Algoma and Gonam rivers, Sakha (Yakutia), Russia, holotype, YaFAN 84/3; *a,* longitudinal section, ×1.5; *b,* detail of wall in tangential section, ×10 (Korshunov, 1968).

Family URANOSPHAERIDAE R. Bedford & J. Bedford, 1936

[Uranosphaeridae R. Bedford & J. Bedford, 1936, p. 22] [=family Uranosphaeraceae R. Bedford & J. Bedford, 1936, p. 22, *nom. correct.* Nitecki & Toomey, 1979, p. 728, *pro* Uranosphaeridae R. Bedford & J. Bedford, 1936, p. 22; =Uranosphaerinae R. Bedford & J. Bedford, 1936, p. 22, *nom. transl.* Zhuravlev & Sayutina, 1985, p. 60, *ex* Uranosphaeridae R. Bedford & J. Bedford, 1936, p. 22]

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

Uranosphaera R. Bedford & W. R. Bedford, 1934, p. 7 [**U. polyaster*; SD R. Bedford & W. R. Bedford, 1936, p. 20; holotype, R. Bedford & W. R. Bedford, 1934, fig. 35; Debrenne, H. Termier, & G. Termier, 1971, pl. 29,*3–6;* M, S4199, NHM, London] [?=*Kuraya* Romanenko, 1968, p. 135 (type, *K. sphaerica,* OD)]. Cup globular, nesasters linked. *lower Cambrian (?Bot.1, Bot.3)*: ?Altay Sayan, Australia.——Fig. 660,*2a–c*. **U. polyaster*, Ajax Limestone, Botoman, Ajax Mine, South Australia, Australia, holotype, NHM S4199; *a,* distal view, ×2.5; *b,* lower view, ×2.5; *c,* external tangential view of wall, ×6 (Debrenne, H. Termier, & G. Termier, 1971).

Class UNCERTAIN

MORPHOLOGICALLY SIMILAR BUT PROBABLY NOT ALLIED TO ARCHAEOCYATHA OR RADIOCYATHA

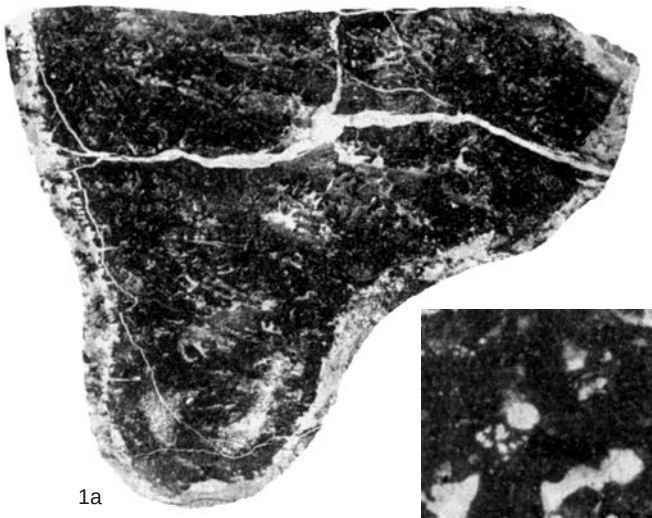
Acanthinocyathus R. Bedford & W. R. Bedford and *Osadchiites* Zhuravleva share a morphology of radial rods linking more or less identical units of the inner and outer wall, a character reminiscent of Radiocyatha (Nitecki & Debrenne, 1979, p. 14; Debrenne, Zhuravlev, & Rozanov, 1989, p. 77). In their original description of *Acanthinocyathus*, R. Bedford and W. R. Bedford (1934) drew attention to a similarity with the archaeocyath *Dokidocyathus* Taylor, which also bears radial intervallar rods in some species. R. Bedford & W. R. Bedford (1934) and Okulitch (1935b) viewed the walls as consisting of fused spicular elements, implying affinity with spiculate sponges. Most authors have nevertheless included *Acanthinocyathus* among the Archaeocyatha.

Acanthinocyathus R. Bedford & W. R. Bedford was known only from silicified specimens until well-preserved calcitic specimens with archaeocyath-like microgranular microstructure were described by Kruse (1982). Despite this microstructural similarity, the genus has been excluded from the Archaeocyatha by Debrenne, Zhuravlev, and Rozanov (1989).

Order ACANTHINOCYATHIDA R. Bedford & W. R. Bedford, 1936

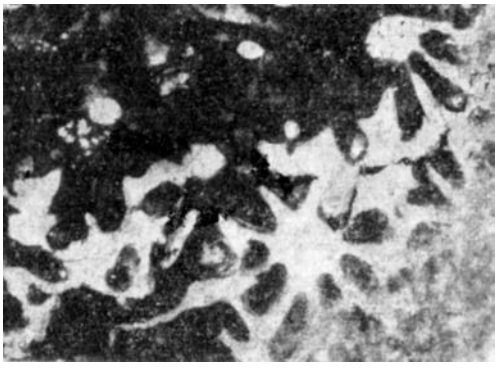
[Acanthinocyathida R. Bedford & W. R. Bedford, 1936, p. 11, *nom. correct.* Vologdin, 1962a, p. 131, *pro* order Acanthinocyathina R. Bedford & W. R. Bedford, 1936, p. 11; *nom. nov. pro* Acanthocyathina Okulitch, 1935b, p. 90, invalid name based on junior homonym]

Cup conical to subcylindrical, two-walled; intervallum with radial rods arranged in longitudinal radial planes, rods linking



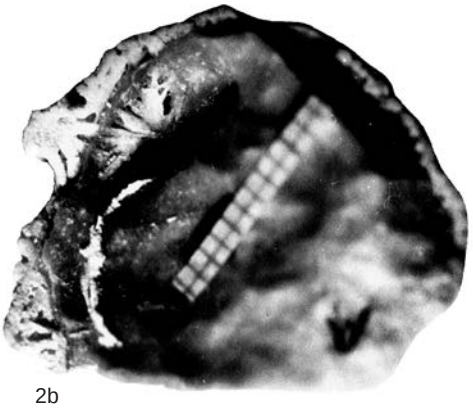
1a

Gonamispongia



1b

2a



2b

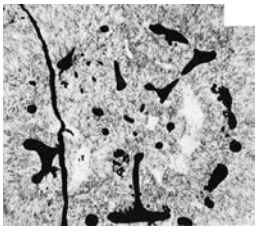
Uranosphaera

2c

FIG. 660. Hetairacyathidae and Uranosphaeridae (p. 1090).

1a

1b



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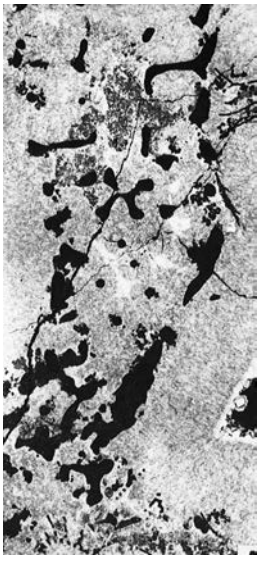
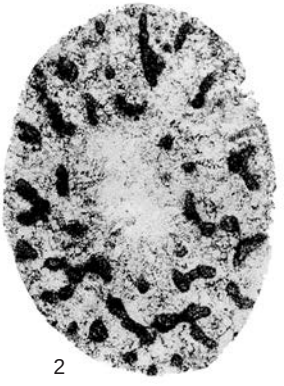


1d

Acanthinocyathus



2

Osadchiites

FIG. 661. Acanthinocyathidae (p. 1093).

corresponding intersections of inner and outer wall structures. *lower Cambrian (Atd.1–Bot.3).*

Family ACANTHINOCYATHIDAE R. Bedford & W. R. Bedford, 1936

[Acanthinocyathidae R. Bedford & W. R. Bedford, 1936, p. 11, *nom. nov. pro* Acanthocyathidae R. Bedford & W. R. Bedford, 1934, p. 4, invalid name based on junior homonym] [=Acantinocyathidae Zhuravleva, Konyushkov, & Rozanov, 1964, p. 99, *nom. null.*]

Outer and inner walls simple, each constructed of two sets of intersecting tangential diagonal rods. *lower Cambrian (Atd.1–Bot.3).*

Acanthinocyathus R. Bedford & W. R. Bedford, 1936, p. 11, *nom. nov. pro Acanthocyathus* R. Bedford & W. R. Bedford, 1934, p. 4 (type, *A. apertus* R. Bedford & W. R. Bedford, 1934, p. 4, M), *non* Milne-Edwards & Haime, 1848, p. 292, cnidarian [**Acanthocyathus apertus* R. Bedford & W. R. Bedford, 1934, p. 4; M; lectotype, Hill, 1965, pl. 2,*3;* Debrenne, 1969a, pl. 2,*3;* SD Debrenne, 1969a, p. 307, S4166, NHM, London] [=*Acantinocyathus* Zhuravleva, Konyushkov, & Rozanov, 1964, p. 100, *nom. null.*]. Outer and inner walls with subrounded to diamond-shaped pores in one longitudinal row per intersept, each outer wall pore bearing an upwardly projecting cornute spine. *lower Cambrian (Bot.3)*: Australia, Antarctica.——Fig. 661,*1a–d*. **A. apertus* (R. Bedford & W. R. Bedford); *a–b,* Ajax Limestone, Botoman, Ajax Mine, South Australia, Australia, lectotype, NHM S4166; *a,* longitudinal view, ×2.5; *b,* longitudinal view, ×2.5 (Hill, 1965); *c–d,* Cymbric Vale Formation, Botoman, Mount Wright, New South Wales, Australia, AM F.83608; *c,* transverse section, AM FT.14180, ×3; *d,* longitudinal section, AM FT.14179, ×3 (Kruse, 1982).

Osadchiites Zhuravleva in Zhuravleva & others, 1997b, p. 167 [**O. denaevadae*; OD; holotype, Zhuravleva & others, 1997b, pl. 13,*3*, 917/5, TsSGM, Novosibirsk]. Outer and inner walls with subrounded to diamond-shaped pores in one longitudinal row per intersept, each outer wall pore bearing an upwardly projecting cornute spine; intervallar rods linked by subsidiary lintels. *lower Cambrian (Atd.1–Atd.2)*: Altay Sayan, Mongolia.——Fig. 661,*2*. **O. denaevadae*, Usa Formation, Atdabanian, Kiya River, Kuznetsk Alatau, Altay Sayan, Russia, holotype, TsSGM 917/5, transverse section, ×8 (Zhuravleva & others, 1997b).

CRIBRICYATHS AND CRIBRICYATH-LIKE TAXA: SYSTEMATIC DESCRIPTIONS

A. Yu. Zhuravlev and P. D. Kruse

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

Vologdin (1966, p. 16) defined the class Cribricyathea as having "cups elongate or isometric, one-walled and two-walled. Walls built by transversely oriented ribbonlike 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. 662). External surfaces of peripterates can be covered by longitudinal rodlike elements (baculi). The inner wall, if present, is excentric, 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 μm) 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 for the consistent co-occurrence of any pair or set of archaeocyathan and cribricyathan taxa is lacking. Furthermore, cribricyaths were much more restricted in space and time than were archaeocyaths.

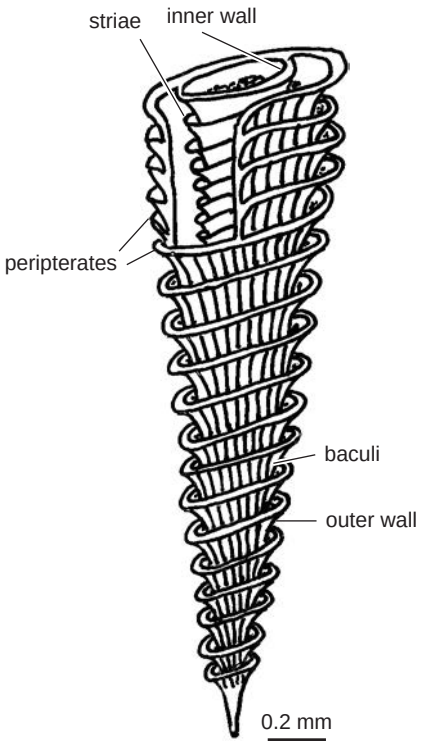


FIG. 662. Reconstruction of cribricyath skeleton as loosely exemplified by *Dolichocyathus* VOLOGDIN, based on etched and thin-sectioned specimens, Tuva, Russia, external longitudinal view, ×10 (Zhuravlev & Kruse, 2012).

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

The earliest cribricyaths are known from the middle Tommotian of East Sayan. During the Atdabanian and Botoman, they become 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 (1964a, 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 cribricyath 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* Cribricyathea VOLOGDIN, 1964a, p. 1392, *nom. correct. pro* Cribrocyathea VOLOGDIN, 1961a, 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* Vologdinophyllacea Jankauskas, 1969, p. 134, *nom. transl. ex* Vologdinophyllidae Radugin, 1964, p. 145]

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

Family VOLOGDINOPHYLLIDAE Radugin, 1964

[Vologdinophyllidae 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.*; =*Costophullum* 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. semicirculare*, 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. asimmetricum*, 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. 663,*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. basaica*; 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 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.*

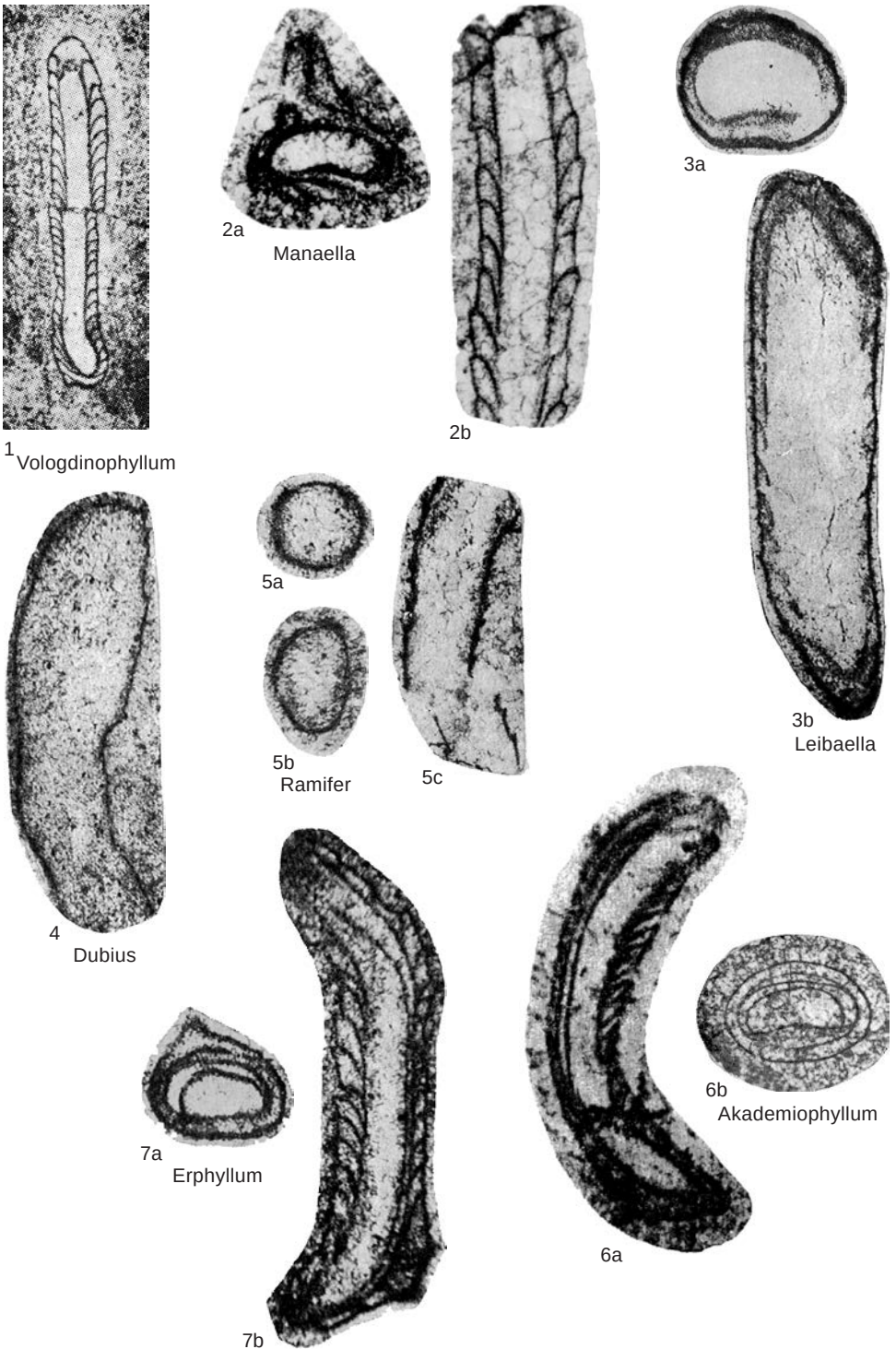


FIG. 663. Vologdinophyllidae, Leibaellidae, and Akademiophyllidae (p. 1097–1100).

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. 663,*2a–b*. **M. basaica*, Bazaikha Formation, Atdabanian, Bazaikha River, East Sayan, Altay 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. ungutica* 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. 663,*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. 663,*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. 663,*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. cornuforme;* 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, Far East.——FIG. 663,*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, ×28 (Radugin, 1964); *b,* topotype TPI collection

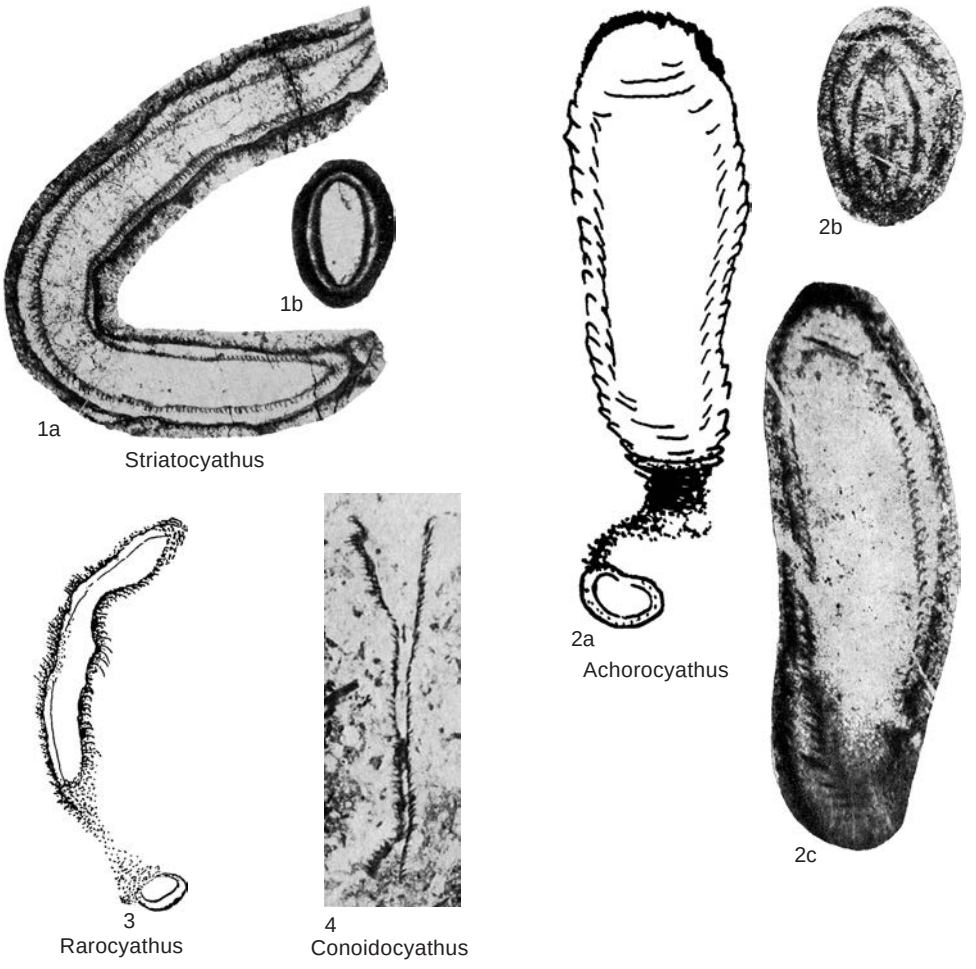


FIG. 664. Striatocyathidae and Conoidocyathidae (p. 1100–1101).

5, locality 61r8, specimen 111, transverse section, ×20 (Jankauskas, 1969).

Erphyllum RADUGIN, 1966, p. 107 [**E. bephylleforme;* OD; holotype, RADUGIN, 1966, pl. 7,*36*, collection 61r, specimen 8-46-1, TPI, Tomsk] [=*Erphyllum* RADUGIN, 1964, p. 146, n*om. 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. 663,*7a–b*. **E. bephylleforme*, Ungut Formation, Atdabanian, Mana River, East Sayan, Altay Sayan, Russia; *a,* topotype, TPI collection 61r, specimen 8, thin section 32, transverse section, ×20; *b,* topotype, TPI specimen 1, thin section 309, longitudinal section, ×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. 664,*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, ×15; *b,* paratype, TPI thin section 2k-60, transverse section, ×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. 664,*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, ×20; *b,* paratype, TPI collection 5, thin section 62-26, transverse section, ×15; *c,* paratype, TPI collection 5, thin section 62-26, longitudinal section, ×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. 664,*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, ×15 (Vologdin & Jankauskas, 1968).

Order CRIBRICYATHIDA Vologdin, 1961

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

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

Family CONOIDOCYATHIDAE Vologdin, 1964

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

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

Conoidocyathus VOLOGDIN, 1964a, p. 1392 [**C. artus*; M; holotype, VOLOGDIN, 1964a, fig. 1(2); VOLOGDIN, 1966, fig. 4, pl. 1,*5*, 1924/26, PIN, Moscow] [=*Pubericyathus* VOLOGDIN, 1964a, p. 1392, *nom. nud.*, invalid genus-group name based on unavailable type species; ?=*Azyricyathus* VOLOGDIN, 1964a, p. 1392 (type, *A. transseptatus*, OD); =*Pubericyathus* VOLOGDIN, 1966, p. 20 (type, *P. phialiformis*, OD); ?=*Azyrcyathus* VOLOGDIN, 1966, p. 23, *nom. null.*; ?=*Azyrcyathus* 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. 664,*4*. **C. artus*, Usa Formation, Botoman, Sukhie Solontsy Valley, Batenev Range, Kuznetsk Alatau, Altay Sayan, Russia, longitudinal section, ×10 (Vologdin, 1966).

Superfamily PYXIDOCYATHOIDEA Vologdin, 1964

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

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

Family PYXIDOCYATHIDAE Vologdin, 1964

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

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

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

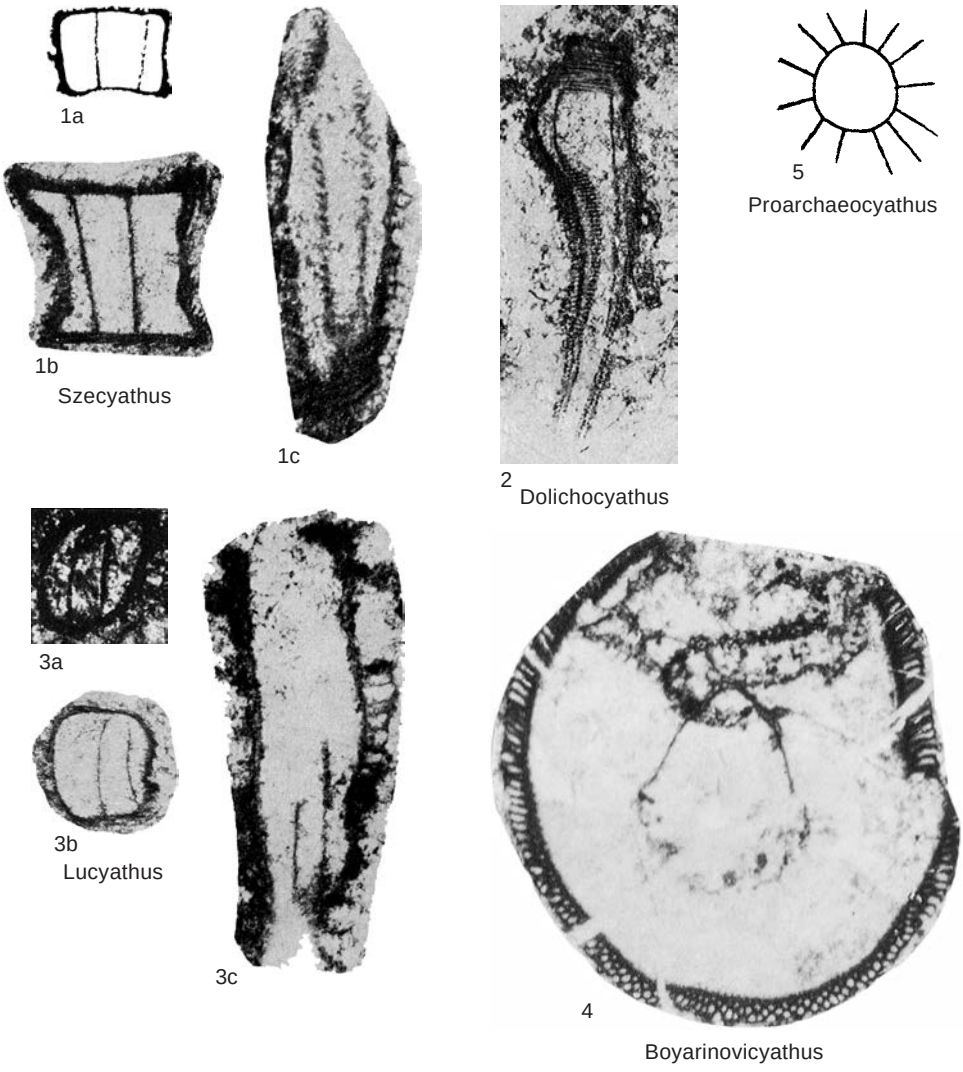


FIG. 665. Pyxidocyathidae, Boyarinovicyathidae, and Cribricyath-like fossils (p. 1101–1103).

designated, collection not located] [=*Cribricyathus* VOLOGDIN, 1964a, p. 1392, *nom. nud.*; =*Lomatiocyathus* VOLOGDIN, 1964a, p. 1392, *nom. nud.*, both invalid genus-group names based on unavailable type species; =*Thecocyathus* VOLOGDIN, 1964a, p. 1392 (type, *T. tetragonus*, OD); =*Pyxidocyathus* VOLOGDIN, 1964a, p. 1394 (type, *P. gracilis*, OD); =*Radicicyathus* VOLOGDIN, 1964a, p. 1394 (type, *R. canaliculatus*, OD); =*Radiacicyathus* VOLOGDIN, 1964a, p. 1394, *nom. null., lapsus calami pro Radicicyathus* VOLOGDIN, 1964a, p. 1394; =*Redicicyathus* VOLOGDIN, 1964a, p. 1394, *nom. null., lapsus calami pro Radicicyathus* VOLOGDIN, 1964a, p. 1394; =*Cribricyathus* VOLOGDIN, 1966, p. 26 (type, *C. longus*, OD); =*Lomaticyathus* VOLOGDIN, 1966, p. 28 (type, *L. clathratus*, OD); =*Thecicyathus* VOLOGDIN, 1966, p. 31, *nom. null., lapsus calami pro Thecocyathus* VOLOGDIN, 1964a, p. 1392; =*Abicyathus* JANKAUSKAS, 1972, p. 172 (type, *Lomaticyathus 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. 665,*1a–c*. **S. cylindricus*; *a,* Verkhneynyrga Formation, Botoman, Lebed' River, Altay Mountains, Altay Sayan, Russia, unlocated topotype, sketch of transverse section, ×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, ×20; *c,* Verkhnemonok Formation, Botoman, Kazly River, West Sayan, Altay Sayan, Russia, TPI collection Jankauskas, 1966, specimen IIIa, thin section 19, longitudinal section, ×25 (Jankauskas, 1972).

Dolichocyathus Vologdin, 1964a, p. 1394 [**D. effiguratus*; OD; holotype, Vologdin, 1964a, fig. 1(15); Vologdin, 1966, fig. 20, pl. 2,*12,* M, 1924/741, PIN, Moscow] [?=*Apocyathus* Vologdin, 1964a, p. 1394 (type, *A. ovalis*, OD); ?=*Capillicyathus* Vologdin, 1964a, p. 1394 (type, *C. fimbriatus*, OD); ?=*Lagenicyathus* Vologdin, 1964a, 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. 665,*2. *D. effiguratus*, Usa Formation, Botoman, Sukhie Solontsy Valley, Batenev Range, Kuznetsk Alatau, Russia, holotype, PIN 1924/741, longitudinal section, ×10 (Vologdin, 1966).

Lucyathus Vologdin, 1957c, p. 495 [**L. elegans*; OD; syntype(s), Vologdin, 1932, fig. 7a,b,m; Vologdin, 1957c, fig. 1e,zh, 2a–v [left], holotype not designated, collection not located] [=*Longicyathus* Vologdin, 1964a, p. 1394 (type, *L. pubescens*, OD); =*Sunicyathus* Vologdin, 1964a, p. 1394 (type, *S. pulcher*, M); =*Turricyathus* Vologdin, 1964a, p. 1394 (type, *T. procerulus*, OD); =*Peripteratocyathus* Vologdin, 1964a, 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. 665,*3a–c*. **L. elegans*; *a,* Verkhnemonok Formation, Botoman, Sanashtykgol River, West Sayan, Altay Sayan, Russia, unlocated topotype, transverse section, ×20 (Vologdin, 1957c); *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, ×20; *c,* Kacha Formation, Botoman, Kookta River, Transbaikalia, Russia, unlocated specimen collection 451, specimen 321/2, thin section 1, longitudinal section, ×20 (Jankauskas, 1972).

Phylum UNCERTAIN

CRIBRICYATH-LIKE TAXA OF UNCERTAIN AFFINITY

Family BOYARINOVICYATHIDAE Zhuravleva, 1997

[Boyarinovicyathidae Zhuravleva in Zhuravleva & others, 1997b, p. 151]

Boyarinovicyathus Zhuravleva in Zhuravleva & others, 1997b, 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. 665,*4*. **B. alexandri*, Usa Formation, Botoman, Bol'shaya Belokamenka River, Kuznetsk Alatau, Russia, holotype ZSGGU 2329/116, oblique longitudinal section, ×10 (Zhuravleva & others, 1997b).

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. 665,*5*. **P. manae*, Ungut Formation, Atdabanian, Mana River, East Sayan, Altay Sayan, Russia, holotype, TPI collection 61r, specimen 8-100, transverse section, ×7.5 (Radugin, 1964).

ARCHAEOCYATHA AND CRIBRICYATHA *NOMINA NUDA;* TAXA NOT ARCHAEOCYATHA, RADIOCYATHA, OR CRIBRICYATHA

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ARCHAEOCYATHA AND CRIBRICYATHA *NOMINA NUDA*

Argunicyathus Fonin, 1985, p. 27.
Baculocyathus Vologdin, 1940b, p. 27.
Bijacoscinus Krasnopeeva, 1978, p. 81.
Ceratocyathus Gangloff in Rozanov & Gangloff, 1979, p. 57, *non* Seguenza, 1864, p. 430, cnidarian.
Coscinophyllina Radugin, 1966, p. 110.
Coscinophyllum Radugin, 1966, p. 109.
Demboicyathus Vologdin in Krasnopeeva, 1960, p. 40.
Dissocyathus Vologdin, 1962a, p. 117.
GAMOCYATHIDAE Vologdin, 1961, p. 179, invalid family-group name based on unavailable genus name.
Gunnicyathus Han & others, 2008, p. 26.
Involucrocyathus Yang & others, 2007, p. 91.
Leptosocyathella Rozanov, 1973, p. 110.
LYSOCYATHIDAE Boyarinov in Rozanov, 1973, p. 85, invalid family-group name based on unavailable genus name.
Lysocyathus Boyarinov in Rozanov, 1973, p. 61.
Mongolocyathus Rozanov, 1973, p. 38.
Plenocyathus Vologdin, 1962c, p. 13.
Protophyllum Radugin, 1966, p. 114, invalid genus-group name based on unavailable type species.
Sagacyathellus Kashina in Debrenne & Rozanov, 1983, p. 734.
Saocyathus Kashina & Jankauskas, 1973, p. 181.
Saocyathus Kashina in Zhuravleva, 1974b, p. 86.
Serratocyathus Vologdin, 1960, p. 424.
Sheathcyathus Yang & others, 2005, p. 206.
Taschtagolia Radugin, 1966, p. 111, invalid genus-group name based on unavailable type species.
Ulenicyathus Krasnopeeva in Yaroshevich, 1962, p. 117.
Utukcyathus Vologdin in Debrenne, 1964, p. 231.

TAXA THAT ARE NOT ARCHAEOCYATHA, RADIOCYATHA, OR CRIBRICYATHA

Binatocyathus Vologdin, 1963, p. 948 [**B. obliquoseptatus*; OD]. Possible nonspiculate thalamid sponge.
Cornutocyathus Boyarinov in Zhuravleva & others, 1997b, p. 166 [**C. cornutus*; OD]. One-walled cone of probable magnesium calcite skeletal mineralogy; wall thick with long, curved radial spines externally; possibly an eroded archaeocyath.
Buschmannia Kaever & Richter, 1976, p. 28 [**B. roeringi*; OD; holotype, Kaever & Richter, 1976, pl. 4,*3*, B2-358, UM]. Radiating gypsum crystal bundles; for discussion, see Debrenne & Lafuste, 1979; Glaessner, 1980.
Domophyllum Radugin, 1964, p. 146, *nom. nud.*, invalid genus-group name based on unavailable type species; hyolith transverse section.
Lenaella Korde, 1959, p. 626 [**L. reticulata*; OD; holotype, Korde, 1959, fig. 1(1, 4), 1298/496, PIN, Moscow, not located]. Similar to *Tunkia* R. Bedford & J. Bedford (1936, p. 21), a probable alga or small skeletal fossil; for discussion, see Handfield and Hansman (1967).
Maldeotaina Flügel in Flügel & Singh, 2003, p. 368 [**M. composita*; OD]. Possible microstromatolite (for discussion, see Debrenne, Gangloff, & Zhuravlev, 1990, p. 361) or cyanobacterium, alga, or khasaktiid (see Problematic Early Cambrian Record, in Early Evolution of the Paleozoic Stromatoporoidea, p. 577).
MANACYATHIDAE Jankauskas, 1969, p. 154. Probable cyanobacteria.
Manacyathus Jankauskas, 1969, p. 154 [**M. mikroporosus*; OD]. Probable cyanobacterium with affinities to *Obruchevella* Reitlinger, 1948, and especially *Spirellus* Jiang in Luo & others, 1982.

MATTHEWCYATHIDAE Okulitch, 1943, p. 48. Possibly inorganic.

Matthewcyathus Okulitch, 1940, p. 83 [**Archaeocyathus pavonoides* Matthew, 1886, p. 29; OD]. Possibly inorganic.

Misracyathus Vologdin, 1959b, p. 82 [**M. vindhianus*; OD]. Possible alga.

Mussooriella Flügel in Flügel & Singh, 2003, p. 356 [**M. kroli*; OD]. Possible microstromatolite; for discussion, see Debrenne, Gangloff, and Zhuravlev (1990, p. 361).

Pentaphyllum Radugin, 1964, p. 146, *nom. nud.*, invalid genus-group name based on unavailable type species; hyolith transverse section.

Sphaerocyathus Vologdin, 1962c, p. 76 [**S. plasticus*; OD]. Possible micrite envelope.

Tanchocyathus Vologdin, 1963, p. 947 [**T. amgaensis*; OD]. Possible nonspiculate sponge; for discussion, see Debrenne and Reitner (2001, p. 312).

Trifoliophyllum Radugin, 1966, p. 104 [**T. mirabile*; OD; holotype, Radugin, 1966, pl. 7,*29*, collection 61r, specimen 5, TPI, Tomsk] [=*Trifoliophyllum* Radugin, 1964, p. 146, *nom. nud.*, invalid genus-group name based on unavailable type species]. Possible anabaritid cross section.

Trigonophyllum Radugin, 1966, p. 94 [**T. inexpectum*; OD; holotype, Radugin, 1966, pl. 7,*18*, collection 61r, specimen 8-1, TPI, Tomsk] [=*Trigonophyllum* Radugin, 1964, p. 146, *nom. nud.*, invalid genus-group name based on unavailable type species]. Possible hyolith transverse section.

Tuvinia Krasnopeeva, 1972, p. 146 [**T. prima*; OD]. Possible coralomorph.

TUVINIDAE Krasnopeeva, 1972, p. 146. Possible coralomorphs.

Yakovlevites Korde, 1979, p. 126, *nom. nov. pro Yakovlevia* Vologdin, 1931, p. 36, *non* Fredericks, 1925, p. 7, brachiopod [**Yakovlevia granulosa* Vologdin, 1931, p. 36; M] [=*Yakovleviella* Korde, 1975, p. 246 (type, *Y. tuvaica*; M; =*Yakovlevia granulosa* Vologdin, 1931, p. 36), *non* Fomichev, 1953, p. 318, rugosan]. Possible coralomorph; for discussion, see Hill, 1972, p. 132; Sayutina, 1985, p. 70, 73; Zhuravlev, Debrenne, and Lafuste, 1993, p. 367.