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Silurian and Lower Devonian chitinozoan taxonomy and biostratigraphy of the Trombetas Group, Amazonas Basin, northern Brazil

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Abstract. Silurian and Devonian (Lower Lochkovian) chitinozoans from the Trombetas Group, and the basal Jatapu Member of the Maecuru Formation, have been studied in outcrops and shallow borings from the Amazonas Basin, northern Brazil. Outcrops were examined along the Trombetas River and its tributaries, the Cachorro and Mapuera rivers, situated on the northern margin of the Amazonas Basin, and from shallow borings in the Pitinga Formation along the Xingu River at Altamira and Belo Monte, together with outcrops along Igarapé da Rainha and Igarapé Ipiranga on the southern margin of the Amazonas Basin. In addition, nine deep borings in the central part of the Amazonas Basin were used as reference sections. The chitinozoans confirm a Llandovery (Late Rhuddanian–Late Telychian) to Early Wenlock (Sheinwoodian) age for the lower part of the Pitinga Formation, and a Ludlow to Early Pridoli age for the upper part of the Pitinga Formation. The overlying Manacapuru Formation is comprised of lower Pridoli rocks in the basal part, but middle and upper Pridoli strata are missing. The upper part of the formation and the basal part of the Jatapu Member of the Maecuru Formation consist of Lower Lochkovian rocks. Seven chitinozoan assemblages (designated in ascending stratigraphic order 1–7) can be distinguished. Of the 104 chitinozoan species encountered, 51 are left in open nomenclature, and three are newly described (*Ancyrochitina pitingaense*, *Belonechitina*? *plumula* and *Linochitina penequadrata*).

Key words: Silurian, Devonian, Trombetas Group, Chitinozoa, biostratigraphy, zonation, Amazonas Basin, Brazil

Introduction

During November 1986 geologists from Eletronorte and the Brazilian national oil company PETROBRAS sampled Paleozoic outcrops along the Trombetas River and its tributaries, the Cachorro and Mapuera rivers. Shallow borings drilled by Eletronorte in that area were also collected at that time (Fig. 1). Shallow drillings along the Xingu River (Fig. 2) at Altamira (Fig. 3A) and Belo Monte (Fig. 3B) were sampled in June 1989. Included in this study are outcrops of Silurian rocks along Igarapé da Rainha and Igarapé Ipiranga (Fig. 3C) on the southern margin of the Amazonas Basin (Costa 1970, 1971), and nine deep borings from the Northern Platform, Central Basin, and Southern Platform (Figs 1A, 2A) which were documented and used as reference sections (Grahn 1988a, b, 1990). The geological results were, in part, included in PETROBRAS internal reports (Grahn 1988a, b, 1990, Grahn and Melo 1990), and published by Azevedo-Soares and Grahn (2005). The Trombetas River has become a classic area for Brazilian Siluro-Devonian geology ever since the American Morgan-expeditions to the Amazonas Basin in 1870 and 1871. Trombetas megafossils collected from

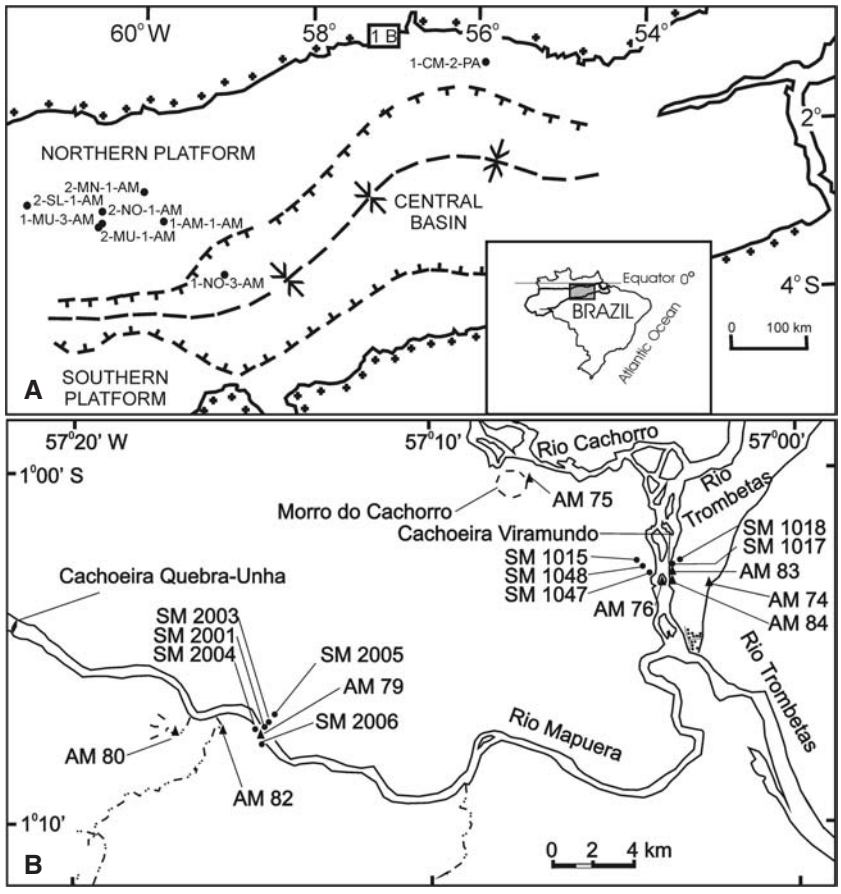

Figure 1. A – location map showing the geographic positions of investigated wells in the Amazonas Basin (Northern Platform and Central Basin) and the Trombetas area (inset 1B), ✚ – outline of the Amazonas Basin. B – location of the outcrop localities and shallow boreholes in the Trombetas area, ▲ – outcrop locality, ● – shallow boreholes.

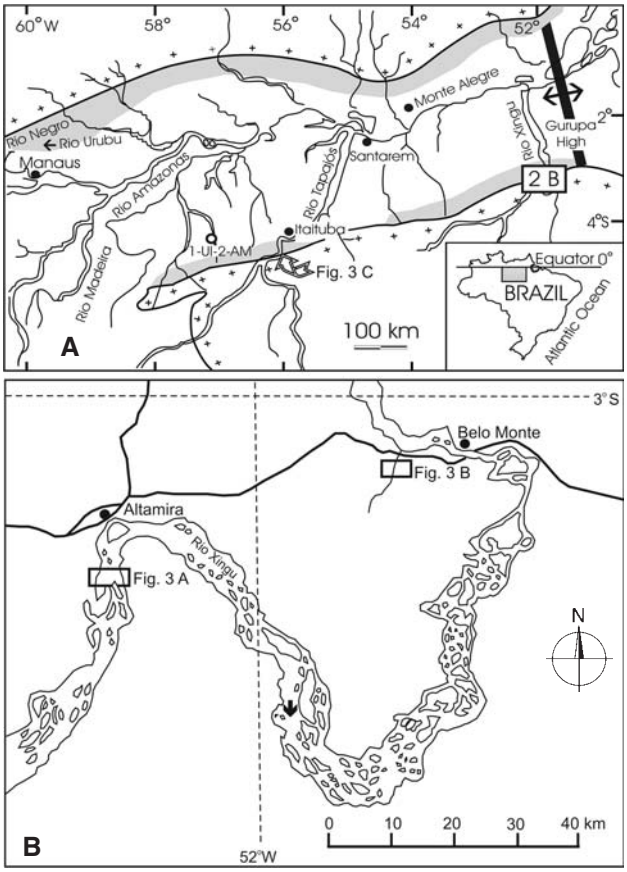

Figure 2. A – location map of the geographic position of the investigated wells on the southern margin of the Amazonas Basin, Igarapé da Rainha and Igarapé Ipiranga area (arrow 3C) and the Xingu River area (inset 2B). Grey area corresponds to the outcrop belts of the Trombetas Group. B –map showing the Altamira (inset 3A) and Belo Monte (inset 3B) areas at the Xingu River.

outcrops along the Cachorro and Trombetas Rivers by these expeditions were first described and published by Derby (1878). Shelly fossils are concentrated in the lower part of the Pitinga Formation (Melo 1988, Grahn 1992a), where they occur together with the Early Silurian graptolites *Climacograptus innotatus brasiliensis* and *Monograptus* cf. *M. gregarius* (Ruedemann 1929, Jaeger 1976). For many years the entire Trombetas Group was considered to be Lower Silurian (Lange 1967, 1972). The first paper documenting chitinozoans from the Trombetas Group was by F. W. Lange in 1967. He also established a biozonation utilizing chitinozoans and acritarchs. According to Lange's (1967) interpretation of the succession, a hiatus corresponding to Lower Llandovery through Emsian strata occurred at the top of the Trombetas Group (then defined in core 35 at a level 1506 m in well 1-AM-1-AM; see Figs 1A and 4). Later, Quadros (1985) found Late Silurian and Lochkovian microfossils below this supposed hiatus, and his observations were confirmed by Grahn (1988a, b, 1992a), Grahn and Paris (1992), and Azevedo-Soares and Grahn (2005). This paper updates the biostratigraphy along the above-mentioned rivers, and compares it with other Silurian and Lower Devonian successions from deep borings in the Amazonas Basin (Figs 1A, 2A). A review of the different Silurian and Lower Devonian formations in the Amazonas Basin was given by Grahn (1992b) and Grahn and Paris (1992).

Material and methods

The locations of the outcrops and borings investigated in this paper are shown in Figs1–3. In total 225 samples were studied from the Pitinga and Manacapuru formations of the Trombetas Group, and the Jatapu Member of the Maecuru Formation, in the Amazonas Basin. The residues were examined for chitinozoans using a binocular stereoscopic microscope, and representative chitinozoan specimens were picked for scanning electron microscope (SEM) studies at the former DIGER/SEGEX (CENPES, PETROBRAS) laboratory in Rio de Janeiro, and in Institute de Géologie at Université de Rennes, Rennes, France. Sample processing and SEM-preparations were done according to the techniques described by Laufeld (1974) and Paris (1981). Photographed chitinozoan specimens are stored at the Department of Stratigraphy and Paleontology at Universidade do Estado do Rio de Janeiro (UERJ/DEPA), and at Institute de Géologie, Université de Rennes (designated by IGR in the plate captions).

Geological setting

The localities in this study cover the northern and southern margins of the Amazonas Basin, and include the central basin where the most complete Siluro-Devonian succession is represented. The Trombetas Group is divided, in ascending order, into Autas-Mirim, Nhamundá, Pitinga (lower and upper), and Manacapuru (lower and upper) formations (Grahn 1992a, Grahn and Paris 1992, Azevedo-Soares and Grahn 2005). It is exposed along the northern margin of the Amazonas Basin from the Gurupa High in the east to Rio Negro in the west, and in two belts along the southern margin of the Amazonas Basin from an area between the Tapajos and Madeira rivers in the west to the Gurupa High (Fig. 2A).

Systematic inventory of chitinozoan species in alphabetical order by genus and species

Ancyrochitina ancyrea (Eisenack 1931). Plate I, fig. 1.
Ancyrochitina cantabrica Cramer and Díez 1978. Plate I, fig. 6.
Ancyrochitina fragilis Eisenack 1955a. Plate I, fig. 8.
Ancyrochitina ollivierae Boumendjel 2002. Plate I, fig. 9.
Ancyrochitina pitingaense n. sp. Plate I, figs 15–16; Plate II, fig. 1.
Ancyrochitina primitiva Eisenack 1964. Plate I, fig. 10; Plate V, fig. 1.
Ancyrochitina regularis Taugourdeau and Jekhowsky 1960. Plate I, figs 11–12.
Ancyrochitina cf. *A. brevis* Taugourdeau and Jekhowsky 1960. Plate I, figs 4–5.

Ancyrochitina aff. *A. asterigis* Paris 1981. Plate I, fig. 3.
Ancyrochitina aff. *A. regularis* Taugourdeau and Jekhowsky 1960. Plate VI, fig. 2.
Ancyrochitina aff. A. tomentosa Taugourdeau and Jekhowsky 1960. Plate I, fig. 13; Plate VI, fig. 1.
Ancyrochitina ex. gr. *ancyrea* (Eisenack 1931). Plate I, fig. 2.
Ancyrochitina ex. gr. *floris* Jaglin 1986. Plate I, fig. 7.
Ancyrochitina sp. A *sensu* Grahn and Paris 1992. Plate VI, fig. 3.
Ancyrochitina n. sp. A. Plate II, fig. 2.
Ancyrochitina n. sp. B. Plate II, fig. 3.
Ancyrochitina n. sp. C. Plate II, fig. 4.
Ancyrochitina n. sp. D. Plate II, fig. 5.
Ancyrochitina n. sp. E. Plate II, fig. 6.
Angochitina echinata Eisenack 1931. Plate II, fig. 8.
Angochitina elongata Eisenack 1931. Plate VI, fig. 4.
Angochitina filosa Eisenack 1955a. Plate II, fig. 10.
Angochitina longicollis Eisenack 1959. Plate II, fig. 11.
Angochitina strigosa Boumendjel 2002. Plate II, fig. 12.
Angochitina n. sp. aff. *A. cyrenaicensis sensu* Grahn and Paris 1992. Plate II, fig. 7.
Angochitina cf. *A. echinata* Eisenack 1931 *sensu* Grahn and Paris 1992. Plate VI, figs 6–7.
Angochitina cf. *A. elongata* Eisenack 1931. Plate VI, fig. 5.
Angochitina sp. aff. *A. mourai* non Lange 1952 *sensu* Schweineberg 1987. Plate V, fig. 2.
Angochitina sp. A *sensu* Grahn and Paris 1992. Plate II, figs 9, 13.
Angochitina sp. B. Plate II, fig. 15.
Angochitina sp. C. Plate II, fig. 16.
Angochitina sp. D. Plate II, fig. 17.
Angochitina cf. *Sphaerochitina densibaculata* Volkheimer et al. 1986. Plate II, fig. 14.
Angochitina? *thadeui* Paris 1981. Plate VII, fig. 11.
Angochitina? sp. *sensu* Grahn and Paris 1992. Plate II, figs 18–19.
Belonechitina? *plumula* n. sp. Plate VI, figs 8–11.
Belonechitina sp. A. Plate V, figs 3–4.
Belonechitina sp. B. Plate V, fig. 13.
Bursachitina wilhelmi (Costa 1970). Plate V, figs 5–6; Plate VII, fig. 2.
Cingulochitina convexa (Laufeld 1974). Plate II, fig. 20; Plate III, fig. 1.
Cingulochitina cylindrica (Taugourdeau and Jekhowsky 1960). Plate III, fig. 18.
Cingulochitina ervensis (Paris in Babin et al.1979). Plate III, fig. 2.
Cingulochitina serrata (Taugourdeau and Jekhowsky 1960). Plate III, fig. 4.
Cingulochitina wronai Paris 1984. Plate III, fig. 6.
Cingulochitina aff. *C. convexa* (Laufeld 1974). Plate II, fig. 21.
Cingulochitina aff. *C. ervensis* (Paris in Babin et al.1979). Plate III, fig. 3.
Cingulochitina aff. *C. serrata* (Taugourdeau and Jekhowsky 1960). Plate III, fig. 5.
Conochitina acuminata Eisenack 1959. Plate III, fig. 8.

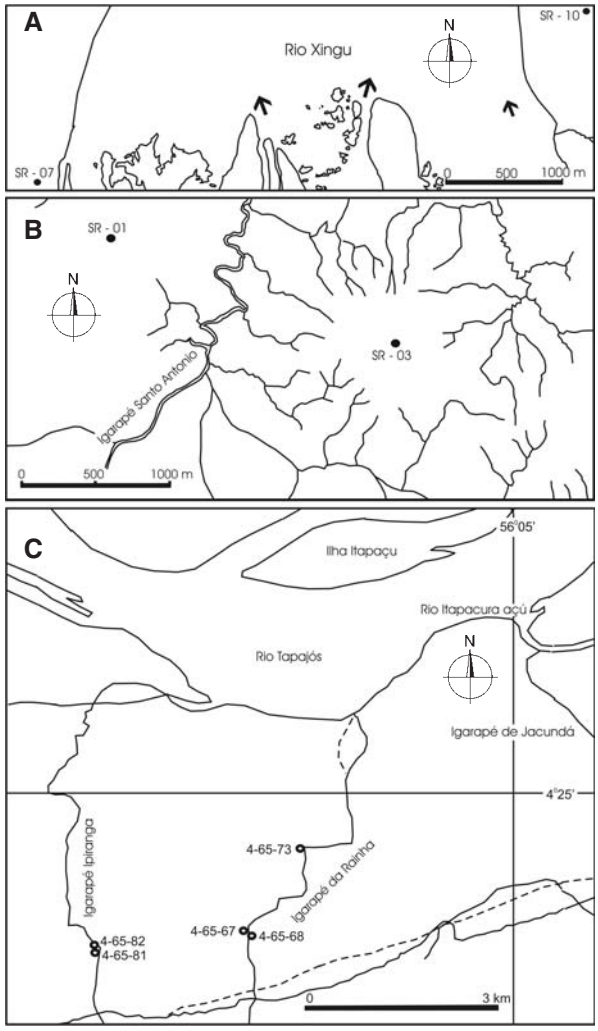

Figure 3. A – detailed locality map of shallow boreholes in the Altamira area. Arrows indicate direction of current. B – detailed locality map of shallow boreholes in the Belo Monte area. C – locality map showing the sampling sites for Silurian Trombetas Group outcrops along Igarapé da Rainha and Igarapé Ipiranga rivers.

Conochitina edjelensis (Taugourdeau and Jekhowsky 1960). Plate V, figs 9, 14.
Conochitina elongata (Taugourdeau and Jekhowsky 1960). Plate V, fig. 8.
Conochitina gordonensis Cramer 1964. Plate III, fig. 9.
Conochitina pachycephala Eisenack 1964. Plate III, figs 11–12.
Conochitina proboscifera Eisenack 1937. Plate III, fig. 13.
Conochitina tuba Eisenack 1932. Plate III, fig. 10.
Conochitina cf. *C. acuminata* Eisenack 1959. Plate VI, fig. 12.
Conochitina cf. *C. tuba* Eisenack 1932. Plate V, fig. 15.
Cyathochitina campanulaeformis (Eisenack 1931). Plate V, fig. 7.
Cyathochitina caputoi Costa 1971. Plate III, fig. 14.
Cyathochitina sp. B *sensu* Paris 1981. Plate III, fig. 15; Plate VI, fig. 13.
Desmochitina densa Eisenack 1962. Plate III, figs 16–17.
Eisenackitina granulata (Cramer 1964). Plate III, fig. 20.
Eisenackitina cf. *E. bohemica* (Eisenack 1934). Plate III, fig. 19.

Figure 4. Lithologic column and chitinozoan range chart for the reference well 1-AM-1-AM. Shaly intervals within the sandstones of the Nhamundá Formation represent interfingering shales of the lower part of the Pitinga Formation.

Euconochitina cruzi Costa 1970. Plate V, fig. 16.
Euconochitina iklaensis (Nestor 1984). Plate III, figs 21–22.
Euconochitina patula (Costa 1971). Plate III, fig. 23.
Euconochitina sulcata (Costa 1971). Plate III, fig. 24.
Euconochitina sp. A. Plate VI, figs 14–15.
Fungochitina kosovensis Paris 1981. Plate III, fig. 25.
Fungochitina sp. A. Plate III, fig. 26.
Lagenochitina aff. *L. navicula* Taugourdeau and Jekhowsky 1960. Plate VI, figs 16–17.
Linochitina penequadrata n. sp. Plate VI, fig. 18. Plate VII, fig. 1.

Linochitina ex. gr. *erratica* (Eisenack 1931). Plate III, fig. 27; Plate V, fig. 17.
Margachitina catenaria Obut 1973. Plate III, fig. 28.
Margachitina margaritana (Eisenack 1937). Plate IV, fig. 1.
Margachitina aff. *M. saretensis* Boumendjel 2002. Plate IV, fig. 2.
Margachitina? sp. Plate VII, fig. 3.
Plectochitina n. sp. A. Plate IV, fig. 3.
Pogonochitina djalmai (Sommer and van Boekel 1965). Plate IV, figs 4–5.
Pogonochitina inornata (Costa 1971). Plate IV, fig. 7.
Pogonochitina tianguaense Grahn et al. 2005. Plate IV, fig. 19.
Pogonochitina cf. *P. djalmai* (Sommer and van Boekel 1965) *sensu* Grahn and Paris 1992. Plate IV, fig. 6.
Pogonochitina n. sp. A. Plate VII, fig. 4.
Pterochitina deichaii Taugourdeau 1963. Plate VII, fig. 13.
Pterochitina megavelata Boumendjel 2002. Plate IV, fig. 8.
Pterochitina perivelata (Eisenack 1937). Plate IV, fig. 9.
Pterochitina sp. A. Plate V, figs 10–11.
Pterochitina sp. B. Plate VII, figs 5–6.
Ramochitina bjornsundquisti Grahn and Melo 2003. Plate IV, fig. 10
Ramochitina illiziensis Boumendjel 1985. Plate VII, fig. 12.
Ramochitina n. sp. cf. *R. devonica* (Eisenack 1955b). Plate IV, fig. 11.
Ramochitina sp. *sensu* Grahn and Paris 1992. Plate VII, figs 7–8.
Ramochitina n. sp. A. Plate I, fig. 14.
Rhabdochitina conocephala? Eisenack 1931 *sensu* Boumendjel 1987. Plate IV, fig. 12.
Sagenachitina sp. A. Plate VII, fig. 9.
Saharochitina gomphos Grahn and Melo 2003. Plate IV, fig. 13.
Salopochitina monterrosae (Cramer 1969). Plate IV, fig. 14.
Salopochitina aff. *S. monterrosae* (Cramer 1969). Plate IV, fig.15.
Sphaerochitina palestinaense Grahn et al. 2005. Plate IV, figs 17–18.
Spinachitina n. sp. A. Plate IV, fig. 16; Plate V, fig. 12.
Tanuchitina elenitae (Cramer 1964). Plate IV, fig. 21.
Tanuchitina aff. *T. cylindrica* (Taugourdeau and Jekhowsky 1960) *sensu* Boumendjel 1987. Plate IV, fig. 20.
Tanuchitina sp. A. Plate VII, fig. 10.
Urochitina n. sp. A. Plate IV, figs 22–23.
Vinnalochitina corinnae (Jaglin 1986). Plate IV, fig. 24.

Systematic paleontology

One hundred and four chitinozoan species have been identified, three of which are newly described, and fifty-one are left in open nomenclature. Their regional stratigraphic ranges for the Amazonas Basin are given in the chapter Chitinozoan biostratigraphy on page 265 and Figs 12, 13, this paper, which includes also seven recently distinguished chitinozoan assemblages. Most of the recovered specimens are compressed, and a correction factor of 0.8 (Paris 1981, Jaglin 1986) was used to calculate the uncompressed dimensions of the specimens (corrected values are given within brackets). The taxonomy follows the scheme proposed by Paris et al. (1999). Only the new species and those left in open nomenclature are described below.

Group Chitinozoa Eisenack 1931
Order Operculatifera Eisenack 1931
Family Desmochitinidae Eisenack 1931 emend. Paris 1981
Subfamily Pterochitininae Paris 1981

Genus *Pterochitina* Eisenack 1955a

Pterochitina sp. A
Plate V, figs 10, 11

Discussion: The velum of this species of *Pterochitina* is situated above the equatorial plane of the vesicle, which is characteristic of *P. perivelata*. Specimens of *P.* sp. A differ in having a smaller velum and comparatively wider body. The contemporaneous species *P. deichaii* Taugourdeau 1963 has a velum below the equatorial plane.

Dimensions (five specimens measured): Total length 59–104 µm, maximum width 113 (90)–212 (170) µm, width of aperture 59–125 µm, maximum width of velum ca 15 µm.

Occurrence: Amazonas Basin, shallow boreholes SM 1015, SM 1017, SM 1018, and SM 1047 (Figs 1B, 5). Lower part of the Pitinga Formation. Assemblage 3, see Fig. 12.

Pterochitina sp. B
Plate VII, figs 5, 6

Discussion: The velum of *Pterochitina* sp. B is situated at the equatorial plane, and consists of four thin annular structures. These are a characteristic feature of *Pterochitina* sp. B, and separates this species from other *Pterochitina* species in the Trombetas Group.

Dimensions (16 specimens measured): Total length 38–58 µm, maximum width 84 (67)–105 (84) µm, width of aperture 46 (37)–50 (40) µm, maximum width of annular structure ≤ 4 µm.

Occurrence: Amazonas Basin, shallow boreholes SR 01, SR 03, and SR 07 (Figs 2B, 3A–B, 6–8). Lower part of the Pitinga Formation. Assemblage 3, see Fig. 12.

Genus *Cingulochitina* Paris 1981

Cingulochitina aff. *C. convexa* Laufeld 1974
Plate II, fig. 21

2005 *Cingulochitina* cf. *C. convexa* – Azevedo-Soares and Grahn, Fig. 4:13

Discussion: *Cingulochitina* aff. *C. convexa* differs from *C. convexa* Laufeld 1974 by being smaller in size and having less convex flanks.

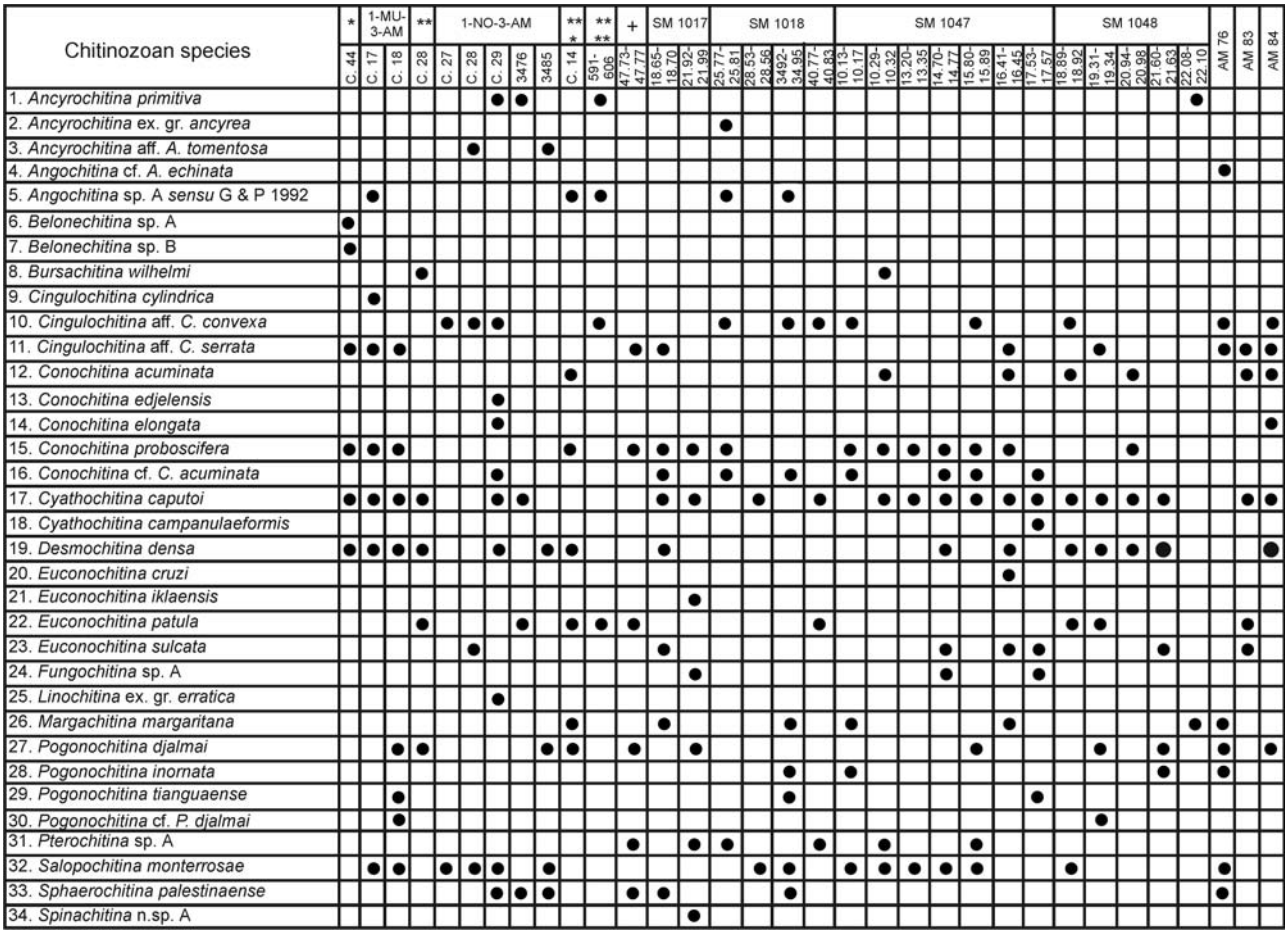

Figure 5. Chitinozoan distribution chart for various wells and outcrops containing assemblages 1–3 on the northern margin and central part of the Amazonas Basin. * = 1-CM-2-PA. ** = 2-MU-1-AM. *** = 2-NO-1-AM. **** = 2-SL-1-AM. + = SM 1015. C = core. For localities see Fig. 1.

Dimensions (62 specimens measured): Total length 103–183 µm, maximum width 50 (40)–80 (64) µm, width of aperture 33 (26)–56 (45) µm, length of neck 1/3–1/2 of the total length.

Occurrence: Amazonas Basin, PETROBRAS 1-AM-1-AM, 1-NO-3-AM and 2-SL-1-AM wells (Figs 1A, 4, 5), shallow boreholes SM 1015, SM 1018, SM 1047, and SM 1048 (Figs 1B, 5), outcrop localities AM 76 and AM 78 (Figs 1B, 5). Lower part of the Pitinga Formation (Azevedo-Soares and Grahn 2005). Assemblages 2 and 3, see Fig. 12.

Cingulochitina aff. *C. ervensis* Paris (in Babin et al. 1979)
Plate III, fig. 3

2003 *Cingulochitina* aff. *C. ervensis* – Grahn and Melo, p. 375, 377, Plate 4, figs 8–9 (see for additional references)
2005 *Cingulochitina* aff. *C. ervensis* – Azevedo-Soares and Grahn, Fig. 4:14

Discussion: The specimens of *Cingulochitina* aff. *C. ervensis* from the Trombetas area are larger than those from the Urubu area, described by Grahn and Melo (2003). *Cingulochitina* aff. *C. ervensis* differs from *C. serrata* by having more convex flanks.

Dimensions (16 specimens measured): Total length 115–200 µm, maximum width 63 (50)–81 (65) µm, width of aperture 46 (37)–56 (45) µm, length of neck 1/4–1/3 of the total length.

Occurrence: Amazonas Basin, PETROBRAS 1-AM-1-AM well (Figs 1A, 4), shallow borehole SM 1048 (Figs 1B, 9). Upper part of the Pitinga Formation (Azevedo-Soares and Grahn 2005). Assemblages 4 and 5, see Fig. 13. Similar specimens have been reported from lower part of the Manacapuru Formation (Late Ludlow?–Early Pridoli) in the Urubu area of the Amazonas Basin (Grahn and Melo 2003).

Cingulochitina aff. *C. serrata* (Taugourdeau and Jekhowsky 1960)
Plate III, fig. 5

1971 *Desmochitina cingulata* – Costa, p. 88–89, Plate 18, fig. 3
1971 *Desmochitina cingulata serrata* – Costa, p. 89–90, Plate 18, figs 4–8
1992 *Cingulochitina* sp. aff. *serrata* – Grahn and Paris, Plate 1, fig. 10
2003 *Cingulochitina* aff. *C. serrata* – Grahn and Melo, p. 377, Plate 4, fig. 10

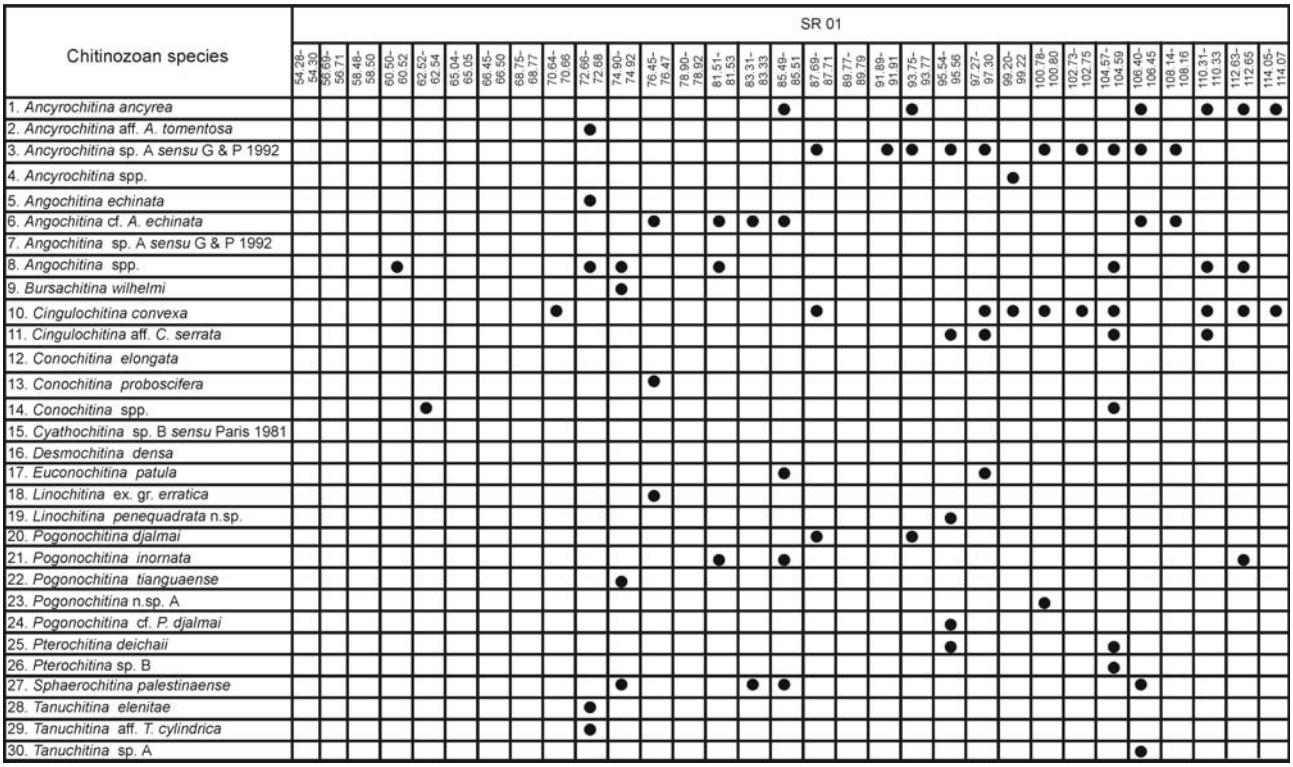

Figure 6. Chitinozoan distribution chart for the SR 01 well on the southern margin of the Amazonas Basin. For the location see Fig. 3B.

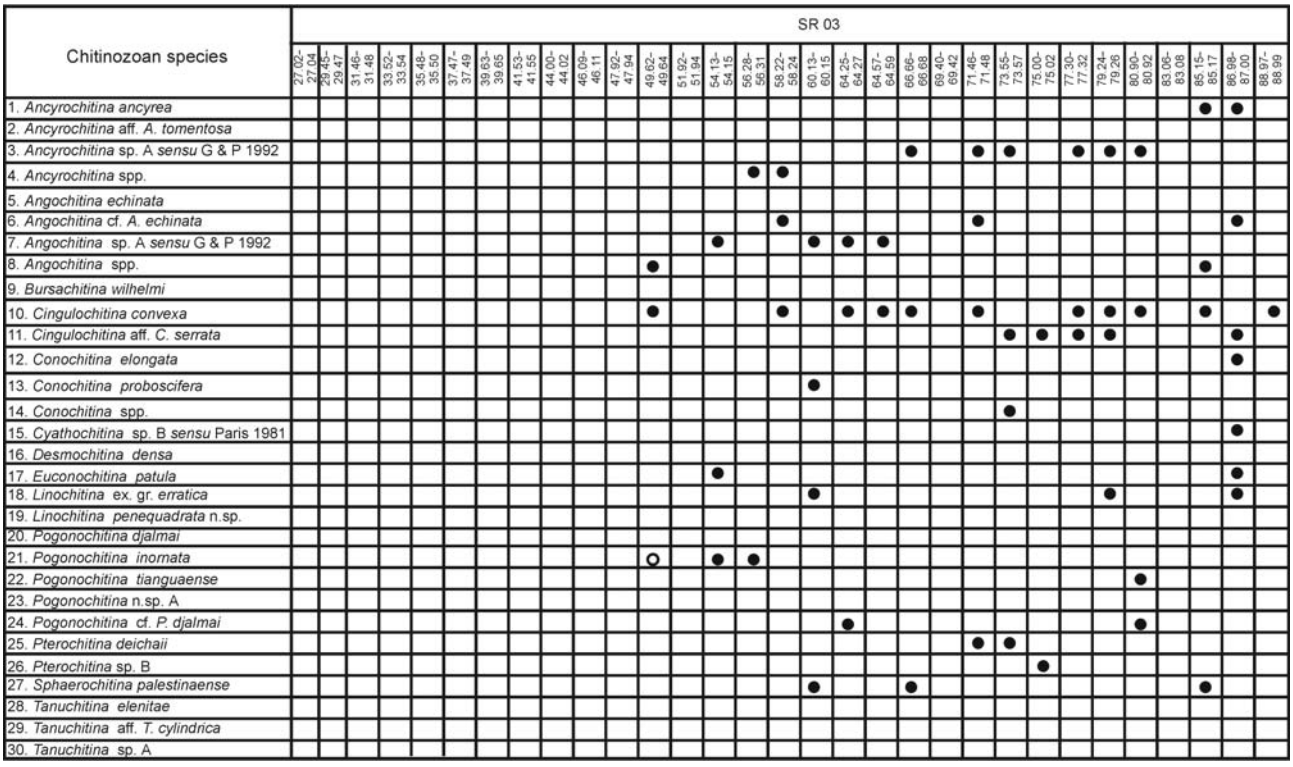

Figure 7. Chitinozoan distribution chart for the SR 03 well on the southern margin of the Amazonas Basin. For the location see Fig. 3B.

Discussion: This species was discussed by Grahn and Melo (2003). *Cingulochitina serrata* (Taugourdeau and Jekhowsky 1960) has straighter flanks and a longer neck than *C.* aff. *C.* serrata.

Dimensions (37 specimens measured): Total length 60–150 µm, maximum width 54 (43)–120 (96) µm, width of aperture 41 (33)–90 (72) µm, length of neck 1/3–1/2 of the total length.

Occurrence: Amazonas Basin, PETROBRAS 1-AM-1-AM, 1-UI-2-AM, 1-CM-2-PA, 1-MU-3-AM, and 2-MU-1-AM wells (Figs 1A, 2A, 4, 5, 11), shallow boreholes SM 1017, SM 1047, SM 1048, SR 01, SR 03, SR 07,

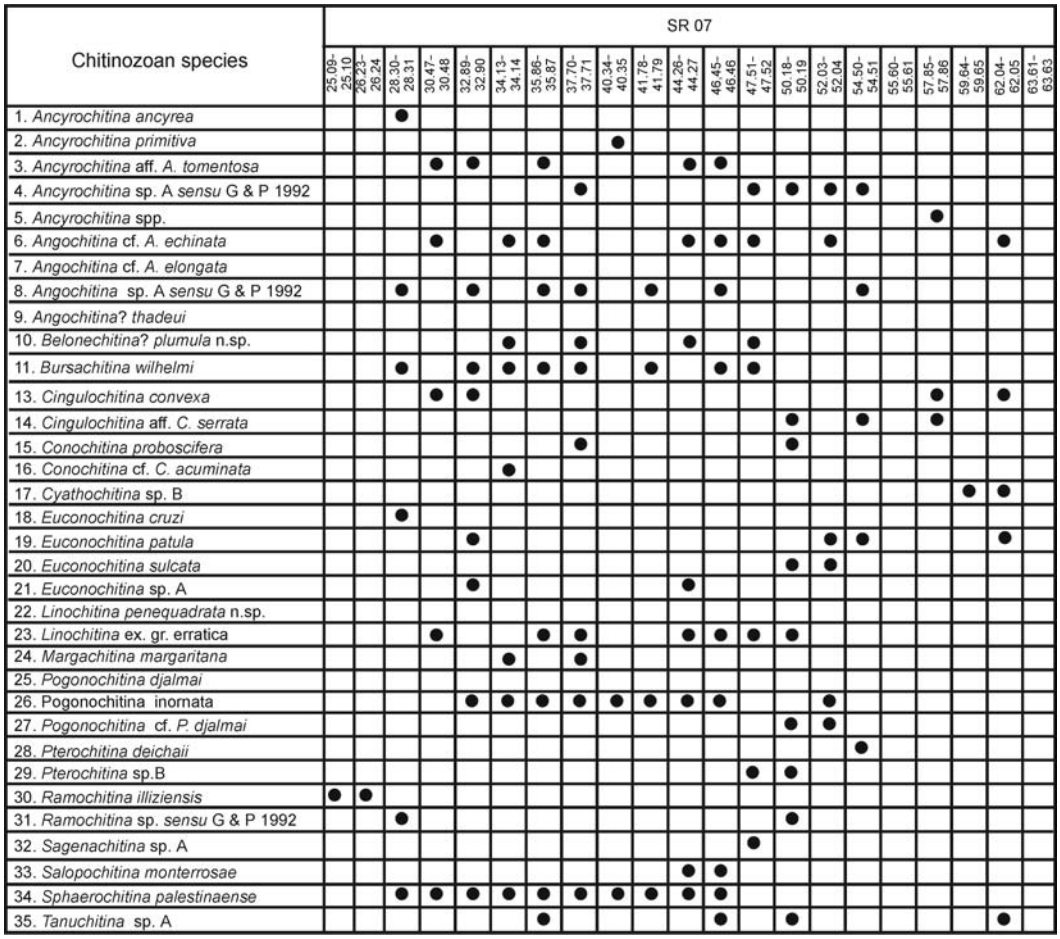

Figure 8. Chitinozoan distribution chart for the SR 07 well on the southern margin of the Amazonas Basin. For the location see Fig. 3A.

and SR 10 (Figs 1B, 2B, 3A–B, 6–8, 10), outcrop localities AM 83, AM 84, Igarapé da Rainha and Igarapé Ipiranga (Figs 1B, 3C, 5, 11). Lower part of the Pitinga Formation in the Trombetas – Xingu area. Assemblages 2 and 3, see Fig. 12, and lower part of the Manacapuru Formation (Late Ludlow–Early Pridoli) in the Urubu area (Grahn and Melo 2003).

Subfamily Margachitininae Paris 1981

Genus *Margachitina* Eisenack 1968

Margachitina aff. *M. saretensis* Boumendjel 2002
Plate IV, fig. 2

2002 *Margachitina* aff. *M. saretensis* – Jaglin and Paris, p. 346–348, Plate 1, fig. 4 (see for additional references)
2003 *Margachitina aff. M. saretensis* – Grahn and Melo, p. 377, Plate 5, figs 7–8
2005 *Margachitina* aff. *M. saretensis* – Azevedo-Soares and Grahn, Fig. 6:2

Discussion: For a discussion of this species, see Jaglin and Paris (2002).

Dimensions (five specimens measured): Total length (excl. peduncle) 100–115 µm, maximum width 98 (77)–118 (94) µm, width of aperture 75 (60)–96 (77) µm, length of peduncle 60–73 µm.

Occurrence: Amazonas Basin, PETROBRAS 1-AM-1-AM and 1-UI-2-AM wells (Figs 1A, 2A, 4, 11), shallow boreholes SM 1015, SM 1018, SM 1047, and SM 1048 (Figs 1B, 9), outcrop locality AM 75 (Figs 1B, 6). Upper part of the Pitinga (Grahn and Melo 2003, Azevedo-Soares and Grahn 2005) and possibly lowermost part of the Manacapuru formations. Assemblages 4 and 5, see Fig. 13. Jaglin and Paris (2002) described this species from the middle Pridoli (*Margachitina elegans* Zone) in the upper part of the Altemances Gréso-argileuses Formation, well A1-61, Tripolitania, northwest Libya.

Margachitina? sp.
Plate VII, fig. 3

Discussion: Only one specimen of this taxon was found, and the lack of essential morphological information concerning the vesicle precludes description.

Dimensions (one specimen measured): Total length (excluding peduncle) unknown, maximum width 91(73) µm, width of aperture 57(46) µm, length of peduncle unknown.

Occurrence: Amazonas Basin, outcrop locality Igarapé da Rainha 4-65-73 (Figs 3C, 11). Lower part of the Pitinga Formation. Assemblage 4, see Fig. 12.

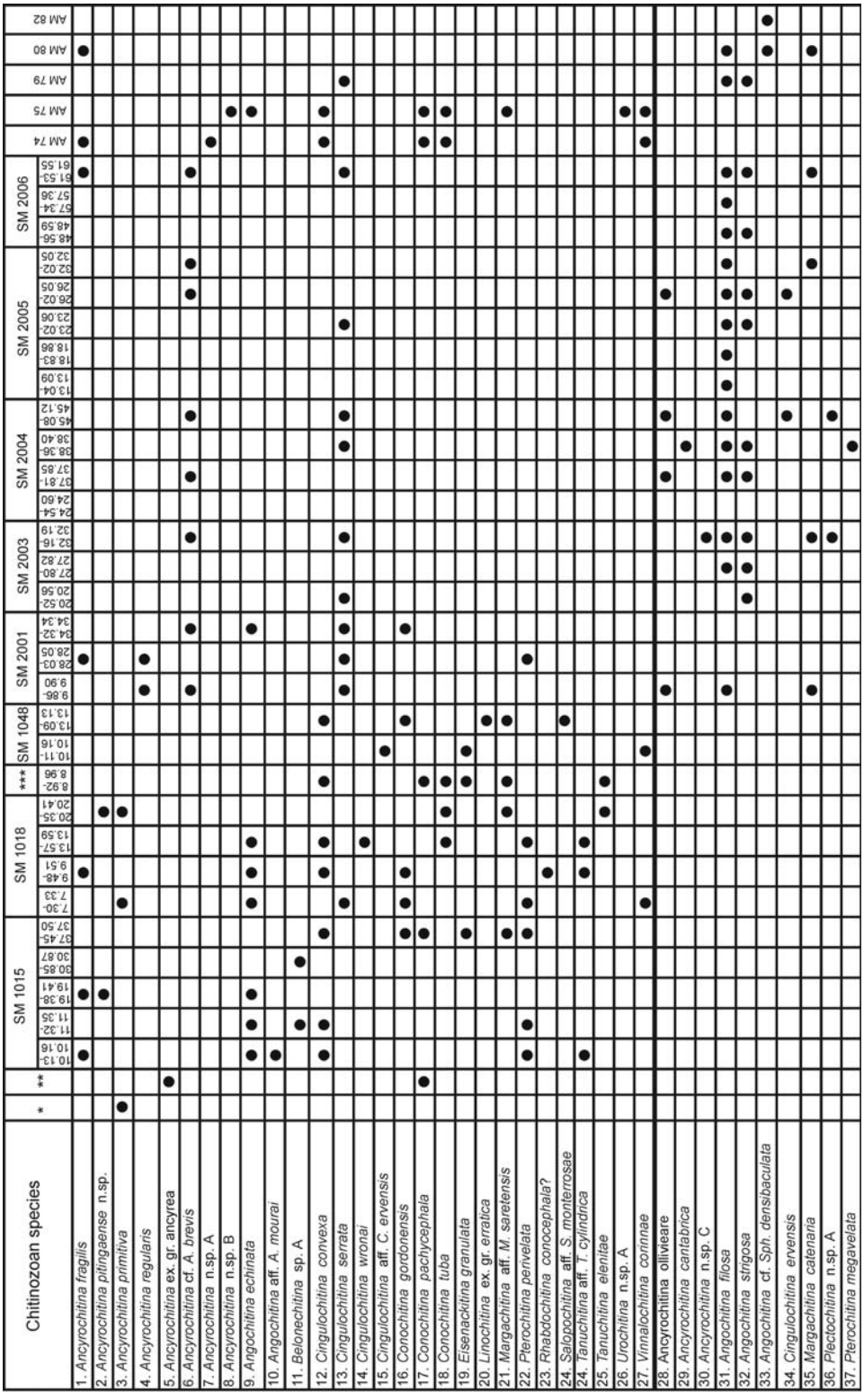

Figure 9. Chitinozoan distribution chart for various wells and outcrops containing assemblages 4–7 on the northern margin of the Amazonas Basin. * – 1-CM-2-PA core 43, ** – 2-MN-1-AM core 42, *** – SM 1047, C – core. For localities see Fig. 1.

Genus *Linochitina* Eisenack 1968 restr. Paris 1981

Linochitina penequadrata n. sp.
Plate VI, fig. 18, Plate VII, fig. 1

Derivation of name: Latin, *pene*, almost, and *quadratum*, four-cornered, referring to the rectangular shape of the species.

Diagnosis: A small *Linochitina* species with a rectangular vesicle outline and bearing a short copula.

Holotype: Plate VI, fig. 18 (lower specimen). UERJ/DEPA SEM collection 04608

Type locality: Well SR 01 (95.54–95.56 m).

Description: Species is easily recognized by its small vesicle size, rectangular vesicle and short copula. The vesicle wall is smooth. A thick rim is present on the basal margin.

Chitinozoan species	SR 10																														
	43.51-43.57	45.10-45.12	46.34-46.36	48.57-48.59	51.79-51.81	53.76-53.78	55.58-55.60	57.17-57.19	59.33-59.35	61.13-61.15	62.79-62.81	64.10-64.12	66.71-66.73	67.87-67.89	71.26-71.28	72.29-72.33	74.85-74.87	76.19-76.22	78.75-78.78	81.75-81.78	84.21-84.23	85.55-85.56	87.93-87.95	90.32-90.34	92.34-92.36	93.80-93.82
1. *Ancyrochitina ancyrea*																															
2. *Ancyrochitina primitiva*																															
3. *Ancyrochitina* aff. *A. tomentosa*												●		●																	
4. *Ancyrochitina* sp. A *sensu* G & P 1992									●												●	●	●								
5. *Ancyrochitina* spp.								●			●													●	●						
6. *Angochitina* cf. *A. echinata*									●	●	●		●		●	●	●	●													
7. *Angochitina* cf. *A. elongata*									●		●																				
8. *Angochitina* sp. A *sensu* G & P 1992														●																	
9. *Angochitina*? *thadeui*								●																							
10. *Belonechitina*? *plumula* n.sp.											●																				
11. *Bursachitina wilhelmi*												●																			
13. *Cingulochitina convexa*											●			●		●				●			●								
14. *Cingulochitina* aff. *C. serrata*																						●	●								
15. *Conochitina proboscifera*																															
16. *Conochitina* cf. *C. acuminata*																															
17. *Cyathochitina* sp. B																															
18. *Euconochitina cruzi*																															
19. *Euconochitina patula*																															
20. *Euconochitina sulcata*																															
21. *Euconochitina* sp. A												●																			
22. *Linochitina penequadrata* n.sp.																					●										
23. *Linochitina* ex. gr. *erratica*										●																					
24. *Margachitina margaritana*																															
25. *Pogonochitina djalmai*																●	●				●	●	●								
26. *Pogonochitina inornata*									●			●	●	●		●															
27. *Pogonochitina* cf. *P. djalmai*																															
28. *Pterochitina deichaii*																							●								
29. *Ramochitina illiziensis*								●																							
30. *Ramochitina* sp. *sensu* G & P 1992																															
31. *Sagenachitina* sp. A																															
32. *Salopochitina monterrosae*											●	●																			
33. *Sphaerochitina palestinaense*									●		●	●		●	●									●							
34. *Tanuchitina* sp. A																															

Figure 10. Chitinozoan distribution chart for the SR 10 well on the southern margin of the Amazonas Basin. For the location see Fig. 3A.

Dimensions (six specimens measured): Total length 100–146 µm. Holotype 118 µm, maximum width 71 (57)–121 (97) µm. Holotype 71(57) µm, width of aperture 59 (47)–106 (85) µm. Holotype 59(47) µm.

Occurrence: Amazonas Basin, shallow boreholes SR 01 and SR 10 (Figs 3A–B, 6, 10). Lower part of the Pitinga Formation. Assemblage 3, see Fig. 12.

Linochitina ex. gr. *erratica* (Eisenack 1931)
Plate III, fig. 27, Plate V, fig. 17

1971 *Desmochitina erratica* – Costa, p. 87–88, Plate 18, figs 1–2

Discussion: For a description of *Linochitina erratica*, see Laufeld (1974). *Linochitina* ex. gr. *erratica* differs from the Baltic specimens in having an ovoid base and indistinct flexure.

Dimensions (29 specimens measured): Total length 94–164 µm, maximum width 31 (25)–64 (51) µm, width of aperture 25 (20)–50 (40) µm, length of neck 1/2 of the total length.

Occurrence: Amazonas Basin, PETROBRAS 1-AM-1-AM and 1-UI-2-AM wells (Figs 1A, 2A, 4, 11), shallow boreholes SM 1048, SR 01, SR 03, SR 07, and SR 10 (Figs 1B, 2B, 3A–B, 6–10), outcrop locality Igarapé da Rainha (Figs 3C, 11). Lower part of the Pitinga Formation. Assemblages 3 and 4, see Fig. 12. Costa (1971) described this species from the Igarapé da Rainha 4-65-68 outcrop.

Subfamily Eisenackitininae Paris 1981

Genus *Eisenackitina* Jansonius 1964

Eisenackitina cf. *E. bohemica* (Eisenack 1934)
Plate III, fig. 19

1967 Tipos 76–77 – Lange, Plate 6, figs 76–77
1992 *Eisenackitina* cf. *bohemica* – Grahn and Paris, Plate 3, fig. 10
2003 *Eisenackitina* cf. *E. bohemica* – Grahn and Melo, p. 377–378, Plate 5, figs 1–2
2005 *Eisenackitina* cf. *E. bohemica* – Azevedo-Soares and Grahn, Fig. 4:18

Discussion: This species was discussed by Grahn and Melo (2003). *Eisenackitina* cf. *E. bohemica* is shorter and has a wider aperture than typical *E. bohemic*a.

Dimensions (two specimens measured): Total length 140–206 µm, maximum width 123 (98)–162 (130) µm, width of aperture 69 (55)–73 (58) µm.

Chitinozoan species	1-UI-2-AM						Igarapé da Rainha			Igarapé Ipiranga	
	Core 9 774.5–778.4	Core 10 779.5–783.5	Core 11 784.5–789.5	Core 12 790.5–795.7	Core 13 796.5	831–834	67	68	73	81	82
1. *Ancyrochitina primitiva*		●		●				●			
2. *Ancyrochitina* aff. *A. regularis*	●										
3. *Ancyrochitina* aff. *A. tomentosa*		●			●						
4. *Ancyrochitina* sp. A *sensu* G & P 1992						●		●			
5. *Ancyrochitina* spp.		●		●							
6. *Angochitina elongata*		●									
7. *Angochitina* cf. *A. echinata*				●	●				●		
8. *Angochitina*? *thadeui*	●										
9. *Angochitina* spp.	●		●								
10. *Bursachitina wilhelmi*							●	●			
11. *Cingulochitina* aff. *C. serrata*		●	●	●				●		●	
12. *Cingulochitina convexa*					●						
13. *Conochitina acuminata*				●							
14. *Conochitina proboscifera*					●						
15. *Conochitina tuba*		●									
16. *Cyathochitina caputoi*							●				
17. *Cyathochitina* sp. B											●
18. *Desmochitina densa*			●	●	●	●					
19. *Euconochitina cruzi*							●	●			
20. *Euconochitina sulcata*					●						
21. *Euconochitina* spp.						●					
22. *Lagenochitina* n.sp. aff. *L. navicula*								●		●	
23. *Linochitina* ex. gr. *erratica*				●				●			
24. *Margachitina margaritana*			●								
25. *Margachitina* aff. *M. saretensis*		●									
26. *Margachitina*? sp.									●		
27. *Pogonochitina djalmai*			●				●	●		●	
28. *Pogonochitina inornata*			●	●				●			
29. *Ramochitina* sp. *sensu* G & P 1992								●	●		
30. *Rhabdochitina conocephala*?									●		
31. *Salopochitina monterrosae*					●					●	
32. *Salopochitina* aff. *S. monterrosae*	●	●									
33. *Tanuchitina* aff. *T. cylindrica*	●	●							●		

Figure 11. Chitinozoan distribution chart in the 1-UI-2-AM well and the outcrops along Igarapé da Rainha and Igarape Ipiranga rivers, southern margin of the Amazonas Basin. For the location see Figs 2A and 3C.

Occurrence: Amazonas Basin, PETROBRAS 1-AM-1-AM well (Figs 1A, 4). Upper part of the Manacapuru Formation. Assemblage 7, see Fig. 13. Grahn and Paris (1992) and Azevedo-Soares and Grahn (2005) reported *E.* cf. *E. bohemica* from the same interval, which includes the lower part of the Jatapu Member of the Maecuru Formation (Fig. 4).

Subfamily Orbichitininae Achab, Asselin and Soufiane 1993

Genus *Salopochitina* Swire 1990

Salopochitina aff. *S. monterrosae* (Cramer 1969)
Plate IV, fig. 15

1967 Tipos 89 a–b, 90 – Lange, Plate 7, figs 89 a–b, 90
1968 *Conochitina filifera* – Jardiné and Yapaudjian, Plate 6, figs 1, 2
2003 *Salopochitina* aff. *S. monterrosae* – Grahn and Melo, p. 379, Plate 6, figs 12, 14, 15

Discussion: This species was described by Grahn and Melo (2003). *Salopochitina* aff. *S. monterrosae* has a granulated vesicle in contrast to *S. monterrosae* which has a smooth vesicle.

Dimensions (three specimens measured): Total length 175–231 µm, maximum width 111 (89)–155 (124) µm, width of aperture 68 (54)–86 (69) µm, length of neck 1/5–1/3 of the total length, length of appendices ≤ 76 µm.

Occurrence: Amazonas Basin, PETROBRAS 1-AM-1-AM and 1-UI-2-AM wells (Figs 1A, 2A, 4, 11), shallow borehole SM 1048 (Figs 1B, 9). Uppermost part of the Pitinga and possibly lowermost part of the Manacapuru (Lange 1967, Grahn and Melo 2003) formations. Assemblage 4, see Fig. 12. Jardiné and Yapaudjian (1968) reported the species as *Conochitina filifera* from the Early Ludlow Médarba Formation, Polignac Basin, Algerian Sahara.

Order Prosomatifera Eisenack 1972
Family Conochitinidae Eisenack 1931 emend. Paris 1981
Subfamily Conochitininae Paris 1981

Genus *Euconochitina* Taugourdeau 1966 emend. Paris et al. 1999

Euconochitina sp. A
Plate VI, figs 14, 15

Discussion: A cylindrical species with a slightly flaring aperture, which is provided with small spines. A thick rim is present on the basal margin. The base is rounded.

Dimensions (three specimens measured): Total length 193–282 µm, maximum width 50 (40)–73 (58) µm, width of aperture 50 (40)–68 (54) µm.

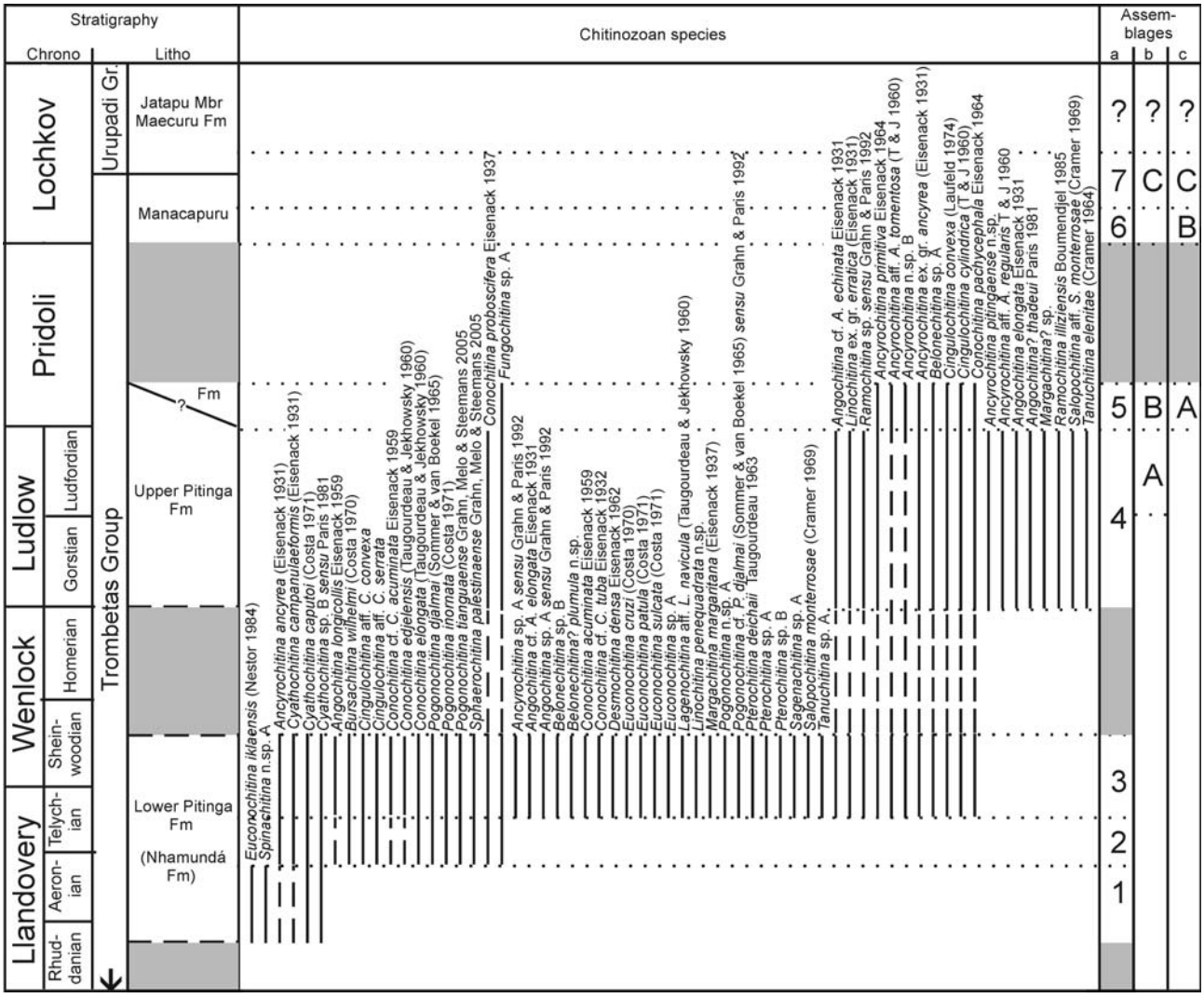

Figure 12. Composite chitinozoan range chart for the Pitinga Formation. a – this paper, b – Grahn and Melo (2003), c – Azevedo-Soares and Grahn (2005), dotted lines – inferred range.

Occurrence: Amazonas Basin, shallow boreholes Sr 07 and SR 10 (Figs 2B, 3A, 8, 10). Lower part of the Pitinga Formation. Assemblage 3, see Fig. 12.

Genus *Conochitina* Eisenack 1931 emend. Paris et al. 1999

Conochitina cf. *C. acuminata* Eisenack 1959
Plate VI, fig. 12

Discussion: For a discussion of *Conochitina acuminata* see Laufeld (1974). *Conochitina* cf. *C. acuminata* differs from the type in having an ovoidal base and a smaller mucron.

Dimensions (two specimens measured): Total length 292–296 µm, maximum width 158 (126)–167 (134) µm, width of aperture 113 (90)–130 (104) µm.

Occurrence: Amazonas Basin, PETROBRAS 1-NO-3-AM well (Figs 1A, 5), shallow boreholes SM 1017, SM 1018, SM 1047, and SR 07 (Figs 1B, 5, 8). Lower part of the Pitinga Formation. Assemblages 2 and 3 see Fig. 12.

Conochitina cf. *C. tuba* Eisenack 1932
Plate V, fig. 15

Discussion: *Conochitina* cf. *C. tuba* differs from *C. tuba* Eisenack 1932 by its convex flanks and ovoid base.

Dimensions (five specimens measured): Total length 226–360 µm, maximum width 115 (92)–153 (122) µm, width of aperture 67 (54)–92 (74) µm, length of neck 1/3 of the total length.

Occurrence: Amazonas Basin, PETROBRAS 1-AM-1-AM well (Figs 1A, 4). Lower part of the Pitinga Formation. Assemblage 3, see Fig. 12.

Genus *Rhabdochitina* Eisenack 1931

Rhabdochitina conocephala? Eisenack 1931 *sensu* Boumendjel 1987
Plate IV, fig. 12

1967 Tipos 51, 99–100 – Lange, Plate 4, fig. 51, Plate 8, figs 99–100

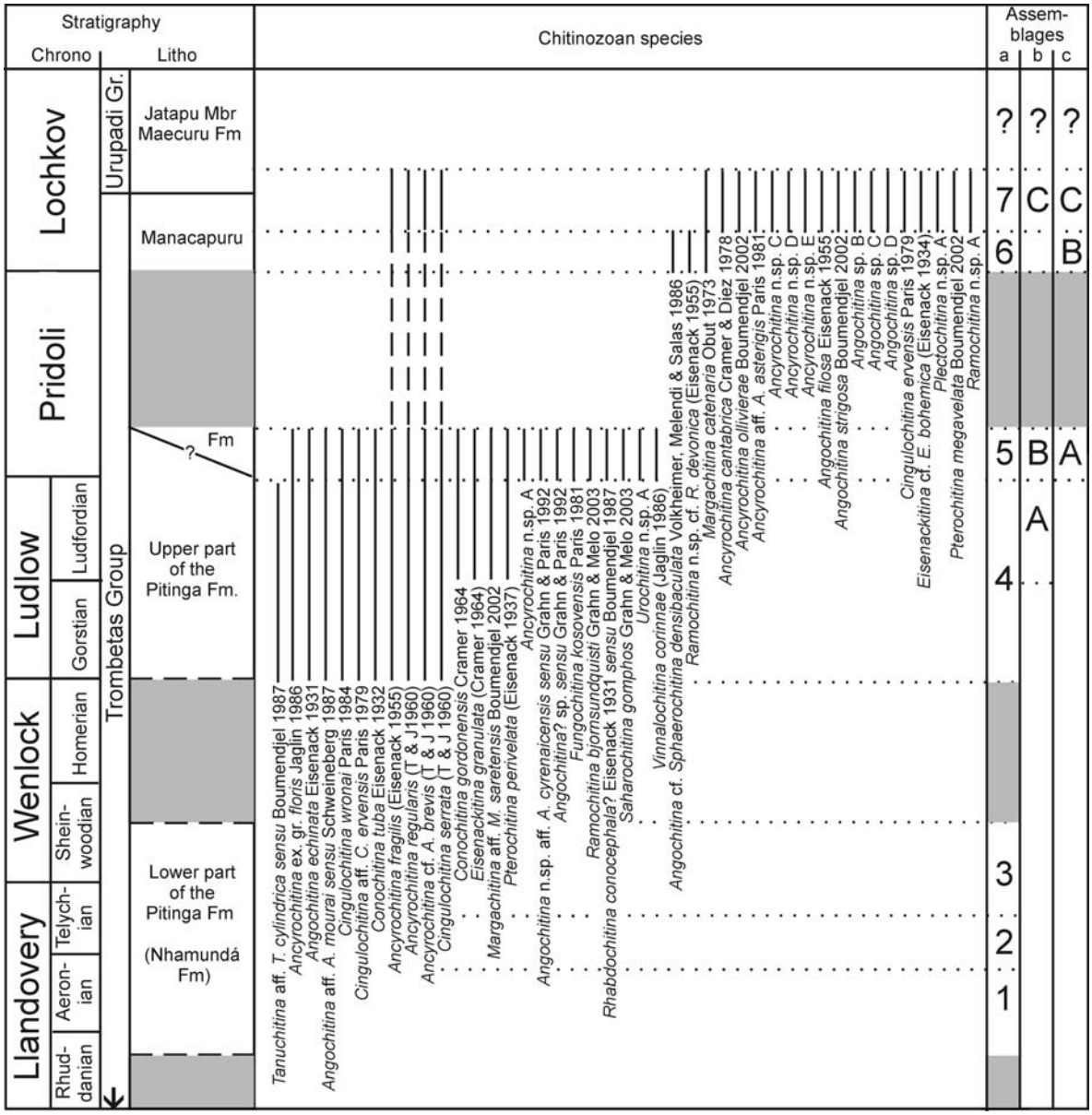

Figure 13. Composite chitinozoan range chart in the upper part of the Pitinga and Manacapuru formations. a – this paper, b – Grahn and Melo (2003), c – Azevedo-Soares and Grahn (2005), dotted lines – inferred range.

1987 *Rhabdochitina conocephala*? – Boumendjel, p. 73–74, Plate 2, figs 4–8

1992 *Rhabdochitina conocephala*? – Grahn and Paris, Plate 2, fig. 7

2003 *Rhabdochitina conocephala*? – Grahn and Melo, p. 379, Plate 6, fig. 13

2005 *Rhabdochitina conocephala*? – Azevedo-Soares and Grahn, Plate 2, fig. 6

Discussion: For a description of this species, see Boumendjel (1987).

Dimensions (three specimens measured): Total length 500–1433 µm, maximum width 85 (68)–158 (126) µm, width of aperture 70 (56)–167 (134) µm.

Occurrence: Amazonas Basin, PETROBRAS 1-AM-1-AM well (Figs 1A, 4), shallow borehole SM 1018 (Figs 1B, 9), outcrop locality Igarapé da Rainha (Figs 3C, 11). Uppermost part of the Pitinga (Lange 1967, Grahn and Paris 1992, Grahn and Melo 2003, and Azevedo-Soares and Grahn 2005) and lowermost part of the Manacapuru formations. Assemblage 5, see Fig. 13. Boumendjel (1987) described *R. conocephala*? from Lower Ludlow beds in the lower part of the Mehaiguène Formation, Oued Mya Basin, Algerian Sahara.

Subfamily Tanuchitininae Paris 1981

Genus *Tanuchitina* Jansonius 1964

Tanuchitina aff. *T. cylindrica* (Taugourdeau and Jekhowsky 1960) *sensu* Boumendjel 1987
Plate IV, fig. 20

?1967 Tipo 97 – Lange, Plate 4, fig. 97

1987 *Tanuchitina* sp. aff. *cylindrica* – Boumendjel, p. 74, Plate 1, figs 4, 8, 9
1992 *Tanuchitina* sp. aff. *cylindrica* – Grahn and Paris, Plate 2, fig. 12
2003 *Tanuchitina* aff. *T. cylindrica* – Grahn and Melo, p. 380, Plate 6, fig. 5

Discussion: For a description of this species, see Boumendjel (1987).

Dimensions (six specimens measured): Total length 360–930 µm, maximum width 80 (64)–120 (96) µm, width of aperture 60 (48)–120 (96) µm, width of carina ca 5 µm.

Occurrence: Amazonas Basin, PETROBRAS 1-AM-1-AM and 1-UI-2-AM wells (Figs 1A, 2A, 4, 11), shallow boreholes SM 1015, SM 1018, and SR 01 (Figs 1B, 2B, 3B, 4, 6, 9), outcrop locality Igarapé da Rainha (Figs 3C, 11). Uppermost part of the Pitinga (Lange 1967, Grahn and Paris 1992, Grahn and Melo 2003) and possibly lowermost part of the Manacapuru formations. Assemblage 4, see Fig. 13. Boumendjel (1987) described *T.* aff. *T. cylindrica* from Lower Ludlow beds in the Mederba Formation, Illizi Basin, Algerian Sahara.

Tanuchitina sp. A
Plate VII, fig. 10

Discussion: A *Tanuchitina* species with an elongated ovoid body, which is slightly convex at the base, and a cylindrical neck. A short carina is present below the basal margin. The aperture is straight.

Dimensions (four specimens measured): Total length 233–300 µm, maximum width 89 (71)–96 (77) µm, width of aperture 68 (54)–77 (62) µm, width of carina 4 µm.

Occurrence: Amazonas Basin, shallow boreholes SR 01 and SR 07 (Figs 2B, 3A–B, 6, 8). Lower part of the Pitinga Formation. Assemblage 3, see Fig. 12.

Subfamily Pogonochitininae Paris et al. 1999

Genus *Pogonochitina* Taugourdeau 1961

Pogonochitina cf. *P. djalmai* (Sommer and van Boekel 1965) *sensu* Grahn and Paris 1992
Plate IV, fig. 6

1971 *Conochitina intermedia* – Costa, p. 34–35, Plate 2, fig. 1
1992 *Pogonochitina* cf. *djalmai* – Grahn and Paris, Plate 2, figs 3, 9a–b

Discussion: *Pogonochitina* cf. *P. djalmai* differs from *P. djalmai* by its wider neck and barrel-shaped body.

Dimensions (six specimens measured): Total length 118–146 µm, maximum width 63 (50)–71 (57) µm, width of aperture 43 (34)–53 (42) µm, length of neck 1/4–1/3 of the total length.

Occurrence: Amazonas Basin, PETROBRAS 1-MU-3-AM well (Figs 1A, 5), shallow boreholes SM 1048, SR 01, SR 03, and SR 07 (Figs 1B, 2B, 3A–B, 5, 6–8). Lower part of the Pitinga Formation. Assemblage 3, see Fig. 12.

Pogonochitina n. sp. A
Plate VII, fig. 4

Discussion: This species has an elongated conical body and a cylindrical neck slightly widening at the straight aperture. The vesicle wall is smooth. A crown with minute simple spines is present at the basal margin.

Dimensions (one specimen measured): Total length 256 µm, maximum width 56 (45) µm, width of aperture 50 (40) µm, length of neck 2/5 of the total length.

Occurrence: Amazonas Basin, shallow borehole SR 01 (Figs 2B, 3B, 6). Lower part of the Pitinga Formation. Assemblage 3, see Fig. 12.

Subfamily Belonechitininae Paris 1981

Genus *Belonechitina* Jansonius 1964

Belonechitina sp. A
Plate V, figs 3–4

Discussion: A conical to subcylindrical species with a wide straight aperture. Base slightly convex. The vesicle wall is covered by small simple spines.

Dimensions (one specimen measured): Total length 191 µm, maximum width 110 (88) µm, width of aperture 71 (57) µm, length of neck 1/3 of the total length.

Occurrence: Amazonas Basin, PETROBRAS 1-AM-1-AM and 1-CM-2-PA wells (Figs 1A, 4, 5), shallow borehole SM 1015 (Figs 1B, 9). Pitinga Formation. Assemblages 3–5, see Fig. 12.

Belonechitina sp. B
Plate V, fig. 13

Discussion: An elongate slender species with a subcylindrical body and a cylindrical neck. The vesicle wall is ornamented by simple spines, which are concentrated on the anteapertural part.

Dimensions (one specimen measured): Total length 400 µm, maximum width 121 (97) µm, width of aperture 92 (74) µm, length of neck 1/3 of the total length.

Occurrence: Amazonas Basin, PETROBRAS 1-CM-2-PA well (Figs 1A, 5). Lower part of the Pitinga Formation. Assemblage 3, see Fig. 12.

Belonechitina? *plumula* n. sp.
Plate VI, figs 8–11

1971 *Illichitina multiplex* Scallreuter – Costa, p. 69–70, Plate 12, fig. 5

Derivation of name: Latin, *plumula*, diminutive of *pluma*, plume, referring to the ornamentation at the aperture.

Diagnosis: A species with a conical body and ovoid base, with a thick ridge at the basal margin. A plume of long simple spines occurs at the aperture.

Holotype: Plate VI, fig. 8. UERJ/DEPA SEM collection 12710

Type locality: Well SR 10 (64.10–64.12 m).

Description: This species is easily distinguished from other chitinozoan species by the plume of long simple spines at the aperture, and a thick ridge along the basal margin. A mucron is present on the base. The vesicle wall is smooth below the aperture. The flexure is indistinct.

Dimensions (five specimens measured): Total length 163–197 µm. Holotype 191 µm; maximum width 59 (47)–75 (60) µm. Holotype 89 (71) µm, width of aperture 59 (47)–72 (58) µm. Holotype 70 (56) µm, length of spines ≤ 74 µm. Holotype 48 µm.

Occurrence: Amazonas Basin, shallow boreholes SR 07 and SR 10 (Figs 2B, 3A, 8, 10). Lower part of the Pitinga Formation. Assemblage 3, see Fig. 12.

Subfamily Spinachitininae Paris 1981

Genus *Spinachitina* Schallreuter 1963

Spinachitina n. sp. A
Plate IV, fig. 16; Plate V, fig. 12

Discussion: A slender conical *Spinachitina* species with a constriction aperturewards of the sharp basal margin, which has a crown of simple appendages. Base flat. Neck cylindrical and slightly widened towards the spiny aperture. *Spinachitina* n. sp. A differs from other Early Silurian *Spinachitina* species (i.e. *S. fragilis*, *S. harringtoni*, *S. maennili*, *S. wolfarti*) by the constriction aperture ward of the basal margin.

Dimensions (two specimens measured): Total length 300–425 µm, maximum width 100 (80)–120 (96) µm, width of aperture 50 (40)–65 (74) µm, length of appendices 7–10 µm, length of neck 1/3 of the total length.

Occurrence: Amazonas Basin, shallow borehole SM 1017 (Figs 1B, 5). Lower part of the Pitinga Formation. Assemblage 1, see Fig. 12.

Family Lagenochitinidae Eisenack 1931 emend. Paris 1981
Subfamily Lagenochitininae Paris 1981

Genus *Lagenochitina* Eisenack 1931 emended Paris et al. 1999

Lagenochitina n. sp. aff. *L. navicula* Taugourdeau and Jekhowsky 1960
Plate VI, figs 16, 17

1971 *Angochitina amazonica* – Costa, p. 60–61, Plate 11, fig. 6
1971 *Angochitina crumena* – Costa, p. 61–62, Plate 11, figs 7–8
1971 *Lagenochitina sommeri* – Costa, p. 73–75, Plate 14, figs 5–8
1971 *Lagenochitina ovoidea* – Costa, p. 75, Plate 14, figs 9–10
1992 *Lagenochitina* n. sp. aff. *navicula* – Grahn and Paris, Plate 1, fig. 11

Discussion: *Lagenochitina* n. sp. aff. *L. navicula* differs from *L. navicula* by having a much shorter neck and almost spherical body. *L. navicula* has elongated ovoid body.

Dimensions (eight specimens measured): Total length 126–177 µm, maximum width 88 (70)–91 (73) µm, width of aperture 44 (35)–47 (38) µm, length of neck 1/4 of the total length.

Occurrence: Amazonas Basin, outcrop localities Igarapé da Rainha 4-65-68 and Igarapé Ipiranga 4-65-81 (Figs 3C, 11). Lower part of the Pitinga Formation (Grahn and Paris 1992). Assemblage 3, see Fig. 12.

Subfamily Cyathochitininae Paris 1981

Genus *Sagenachitina* Jenkins 1970

Sagenachitina sp. A
Plate VII, fig. 9

Discussion: This is a species of *Sagenachitina* with a conical body and a cylindrical neck. The basal margin contains a reticulate carina. The aperture is straight and vesicle wall is smooth.

Dimensions (1 specimen measured): Total length 439 µm, maximum width 156 (125) µm, width of aperture 89 (71) µm, length of neck 1/2 of the total length.

Occurrence: Amazonas Basin, shallow borehole SR 07 (Figs 2B, 3A, 8). Lower part of the Pitinga Formation. Assemblage 3, see Fig. 12.

Genus *Cyathochitina* Eisenack 1955b emend. Paris et al. 1999

C*yathochitina* sp. B *sensu* Paris 1981
Plate III, fig. 15, Plate VI, fig. 13

1971 *Cyathochitina caputoi* – Costa, p. 79–80, Plate 15, fig. 6
1981 *Cyathochitina* sp. B – Paris, p. 299, Plate 19, figs 2–3
1992 *Cyathochitina* sp. – Grahn and Paris, Plate 2, fig. 2
2000 *Cyathochitina* sp. B – Grahn in Grahn et al., Plate 3, fig. 7

Discussion: For a description, see Paris (1981). This small and characteristic species differs from *Cyathochitina caputoi* Costa 1971 in having a much shorter carina and in not having longitudinal ribs on the body.

Dimensions (six specimens measured): Total length 200–250 µm, maximum width 146 (117)–250 (200) µm, width of aperture 58 (46)–88 (70) µm, width of carina ≤ 16 µm, length of neck 1/3 of the total length.

Occurrence: Amazonas Basin (Grahn and Paris 1992), PETROBRAS 1-AM-1-AM well (Figs 1A, 4), shallow boreholes SR 03 and SR 07 (Figs 2B, 3A–B, 7, 8), outcrop locality Igarapé Ipiranga (Figs 3C, 11). Lower part of the Pitinga Formation. Assemblages 1–3, see Fig. 12. Grahn et al. (2000) reported *Cyathochitina* sp. B from Aeronian and Telychian strata, east Paraguay, and Paris (1981) described the species from the Late Llandovery (*turriculatus* Zone) Lande Murée Formation in France, and from coeval beds from Syria.

Subfamily Urochitininae Paris 1981

Genus *Urochitina* Taugourdeau and Jekhowsky 1960

Urochitina n. sp. A
Plate IV, figs 22, 23

2005 *Urochitina* n. sp. A – Azevedo-Soares and Grahn, Plate 2, figs 9, 11.

Discussion: This is a species of *Urochitina* with a hemispherical body and a cylindrical neck. The flexure is distinct and the aperture straight. The vesicle wall is glabrous and the base has a peduncle that tapers distally.

Dimensions (two specimens measured): Total length 230–260 μm, maximum width 97 (78)–116 (93) μm, width of aperture 49 (39)– 63 (50) μm, length of peduncle ≤ 95 μm, length of neck 1/2–2/3 of the total length.

Occurrence: Amazonas Basin, outcrop sample AM 75 (Figs 1B, 9). Upper part of the Pitinga Formation (Azevedo-Soares and Grahn 2005). Assemblage 5, see Fig. 13.

Subfamily Angochitininae Paris 1981

Genus *Fungochitina* Taugourdeau 1966

Fungochitina sp. A
Plate III, fig. 26

2003 *Fungochitina* sp. A – Grahn and Melo, p. 380, Plate 5, figs 3, 4

Discussion: This species was described by Grahn and Melo (2003). It is a *Fungochitina* species with simple spines and few other characteristic features.

Dimensions (four specimens measured): Total length 152–186 μm, maximum width 96 (77)–112 (90) μm, width of aperture 32 (26)–45 (36) μm, length of neck 2/5–1/2 of the total length.

Occurrence: Amazonas Basin, shallow boreholes SM 1017 and SM 1047 (Figs 1B, 5). Pitinga and possibly lowermost part of the Manacapuru formations (Grahn and Melo 2003). Assemblages 2–5, see Fig. 12.

Genus *Angochitina* Eisenack 1931

Angochitina n. sp. aff. *A. cyrenaicensis* Paris 1988
Plate II, fig. 7

1992 *Angochitina* n. sp. aff. *A. cyrenaicensis* – Grahn and Paris, Plate 3, figs 3a–b
2005 *Angochitina* n. sp. aff. *A. cyrenaicensis* – Azevedo-Soares and Grahn, Fig. 24:8

Discussion: For a description of *Angochitina cyrenaicensis*, a Late Givetian species, see Paris (1988). The specimens from the Silurian in the Amazonas Basin are striking in their similarity in the overall shape, but differ in having long hair-like spines and in lacking a collar. *Angochitina cyrenaicensis* has shorter spines arranged in lamellae, simple or multirooted.

Dimensions (one specimen measured): Total length 233 μm, maximum width 56 (45) μm, width of aperture 40 (32) μm, length of neck 1/2 of the total length.

Occurrence: Amazonas Basin, PETROBRAS 1-AM-1-AM well (Figs 1A, 4). Upper part of the Pitinga Formation (Grahn and Paris 1992, Azevedo-Soares and Grahn 2005). Assemblage 5, see Fig. 13.

Angochitina sp. aff. A. *mourai* non Lange 1952 *sensu* Schweineberg 1987
Plate V, fig. 2

1987 *Angochitina* sp. aff. *A. mourai* – Schweineberg, p. 62–63, Plate 4, figs 5–11
2003 *Angochitina* sp. aff. *A. mourai* – Grahn and Melo, p. 380, Plate 2, figs 9, 10

Discussion: This species was discussed by Grahn and Melo (2003). It differs from *A. mourai* Lange 1952 in having simple spines.

Dimensions (two specimens measured): Total length 128–153 μm, maximum width 58 (46)–95 (76) μm, width of aperture 40 (32)–43 (34) μm, length of neck 1/3 of the total length.

Occurrence: Amazonas Basin, shallow borehole SM 1015 (Figs 1B, 6). Upper part of the Pitinga Formation. Assemblages 4, 5, see Fig. 13. Schweineberg (1987) described this species from Upper Ludlow beds in the upper part of the Las Arroyacas Formation, Cantabric Mountains, Palencia, northern Spain.

Angochitina cf. *A. echinata* Eisenack 1931 *sensu* Grahn and Paris 1992
Plate VI, figs 6, 7

Discussion: For a description of *A. echinata* see Laufeld 1974. Specimens of *Angochitina* cf. *A. echinata* differ from the former by having long, simple hair-like spines.

Dimensions (14 specimens measured): Total length 140–229 μm; maximum width 67 (54)–98 (78)

µm, width of aperture 37 (30)–56 (45) µm, length of neck 2/5–1/2 of the total length, length of spines ≤ 10 µm.

Occurrence: Amazonas Basin, PETROBRAS 1-UI-2-AM well (Figs 2A, 11), shallow boreholes SR 01, SR 03, SR 07, and SR 10, outcrop localities Igarapé da Rainha (Figs 2B, 3, 11) and AM 76 (Figs 1B, 5). Lower part of the Pitinga Formation. Assemblages 3, 4, see Fig. 12.

Angochitina cf. *A. elongata* Eisenack 1931
Plate VI, fig. 5

Discussion: For a description of *A. elongata*, see Laufeld (1974). *Angochitina* cf. *A. elongata* differs from *A. elongata* in having a denser ornamentation. In the Brazilian populations, specimens of *A. elongata* s.s. have a more dense ornamentation than those of the Baltic type area.

Dimensions (two specimens measured): Total length 187–239 µm, maximum width 67 (54)–71 (57) µm, width of aperture 33 (26)–36 (29) µm, length of neck 2/5–1/3 of the total length, length of spines 7 µm.

Occurrence: Amazonas Basin, shallow borehole SR 10 (Figs 2B, 3A, 10). Upper part of the Pitinga Formation. Assemblage 3, see Fig. 12.

Angochitina sp. A *sensu* Grahn and Paris 1992
Plate II, figs 9, 13

1971 *Ancyrochitina spinosa* – Costa, p. 57–58, Plate 11, figs 1–2
1992 *Angochitina* sp. A – Grahn and Paris, Plate 2, figs 11a–b

Discussion: A short *Angochitina* species with a spherical body and cylindrical neck that widens slightly towards the aperture. The vesicle is covered by randomly distributed long and simple spines.

Dimensions (seven specimens measured): Total length 105–188 µm, maximum width 81 (65)–100 (80) µm, width of aperture 46 (37)–75 (60) µm, length of neck 2/5–1/2 of the total length, length of spines ≤ 12 µm.

Occurrence: Amazonas Basin, PETROBRAS 1-MU-3-AM, 2-NO-1-AM, and 2-SL-1-AM wells (Figs 1A, 5), shallow boreholes SM 1018, SR 03, SR 07, and SR 10 (Figs 1B, 5, 7, 8, 10). Lower part of the Pitinga Formation. Assemblage 3, see Fig. 12.

Angochitina sp. B
Plate II, fig. 15

2005 *Angochitina* n. sp. B – Azevedo-Soares and Grahn, Fig. 6:7

Discussion: This characteristic species has an ovoid body, and a broad cylindrical neck that widens slightly at the aperture. The vesicle is covered by randomly distributed, minute, simple spines.

Dimensions (three specimens measured): Total length 200–243 µm, maximum width 100 (80)–187 (150) µm, width of aperture 86 (69)–125 (100) µm, length of neck 1/3–2/5 of the total length.

Occurrence: Amazonas Basin, PETROBRAS 1-AM-1-AM well (Figs 1A, 4). Lower part of the Jatapu Member of the Maecuru Formation. Assemblage 7, see Fig. 13.

Angochitina sp. C
Plate II, fig. 16

2005 *Angochitina* n. sp. C – Azevedo-Soares and Grahn, Fig. 6:9

Discussion: This species has a spherical body and a cylindrical neck widening towards the aperture. The vesicle is covered by randomly distributed simple spines.

Dimensions (one specimen measured): Total length 250 µm, maximum width 96 (77) µm, width of aperture 67 (54) µm, length of neck 1/2 of the total length.

Occurrence: Amazonas Basin, PETROBRAS 1-AM-1-AM well (Figs 1A, 4). Uppermost part of the Manacapuru Formation. Assemblage 7, see Fig. 13.

Angochitina sp. D
Plate II, fig. 17

Discussion: An *Angochitina* species with an ovoid body and a short cylindrical neck widening towards the aperture. The vesicle is covered by randomly distributed simple spines.

Dimensions (one specimen measured): Total length 218 µm, maximum width 107 (86) µm, width of aperture 61 (49) µm, length of neck 1/3 of the total length.

Occurrence: Amazonas Basin, PETROBRAS 1-AM-1-AM well (Figs 1A, 4). Uppermost part of the Manacapuru Formation. Assemblage 7, see Fig. 13.

Angochitina? sp.
Plate II, figs 18, 19

1992 *Angochitina*? sp. – Grahn and Paris, Plate 3, fig. 11
2005 *Angochitina*? sp. – Azevedo-Soares and Grahn, Fig. 4:10

Discussion: A slender species questionably referred to *Angochitina* because its general shape. The body is ovoid to spherical, with a long cylindrical neck that widens at the aperture. Small simple spines cover the vesicle. *Angochitina hemeri* Paris and Al-Hajri 1995 is similar but has no ornamentation on the neck.

Dimensions (three specimens measured): Total length 264–333 µm, maximum width 53 (42)–77 (62) µm, width of aperture 27 (22)–36 (29) µm, length of neck 2/3 of the total length.

Occurrence: Amazonas Basin, PETROBRAS 1-AM-1-AM well (Figs 1A, 4). Upper part of the Pitinga Formation (Grahn and Paris 1992, Azevedo-Soares and Grahn 2005). Assemblage 5, see Fig. 13.

Angochitina cf. *Sphaerochitina densibaculata* Volkheimer et al. 1986
Plate II, fig. 14

2005 *Sphaerochitina* aff. *S. densibaculata* – Azevedo-Soares and Grahn, Fig. 6:6, 8

Discussion: For a description of *Sphaerochitina densibaculata*, see Volkheimer et al. (1986). The ornamentation of the *Angochitina* specimens from the Amazonas Basin shows a striking similarity to those of *Sphaerochitina densibaculata*.

Dimensions (nine specimens measured): Total length 147–233 µm, maximum width 100 (80)–116 (93) µm, width of aperture 54 (43)–67 (54) µm, length of neck 1/3–2/3 of the total length, length of spines 5–10 µm.

Occurrence: Amazonas Basin, PETROBRAS 1-AM-1-AM well (Figs 1A, 4), outcrop localities AM 80 and AM 82 (Figs 1B, 9). Lower-middle part of the Manacapuru Formation (Azevedo-Soares and Grahn 2005). Assemblage 6, see Fig. 13.

Genus *Ramochitina* Sommer and van Boekel 1964, emended Paris et al. 1999

Ramochitina n. sp. cf. *R. devonica* Eisenack 1955b
Plate IV, fig. 11

2005 *Ramochitina* n. sp. cf. *R. devonica* – Azevedo-Soares and Grahn

Discussion: This species has an ovoid body and a cylindrical neck. The vesicle displays eight crests of spines that branch at their tips. Each branch is further divided into two branches. *Ramochitina devonica* has its ornamentation concentrated in the lower anteapertural part of the body, and on the upper neck towards the aperture. The neck is also longer than that of *Ramochitina* n. sp. cf. *R. devonica*, which has its ornamentation all along the vesicle. Furthermore, *R. devonica* is a Middle Devonian species.

Dimensions (one specimen measured): Total length 200 µm, maximum width 90 (72) µm, width of aperture 61 (49) µm, length of neck 2/5 of the total length, length of spines *Angochitina hemeri* 30 µm.

Occurrence: Amazonas Basin, PETROBRAS 1-AM-1-AM well (Figs 1A, 4). Lower-middle part of the Manacapuru Formation (Azevedo-Soares and Grahn 2005). Assemblage 6, see Fig. 13.

Ramochitina n. sp. A
Plate I, fig. 14

2005 *Ramochitina* n. sp. B – Azevedo-Soares and Grahn, Fig. 6:18

Discussion: This species has an elongated ovoid body and a short flared neck. The flexure is indistinct. The vesicle has eight crests with long simple spines.

Dimensions (one specimen measured): Total length 197 µm; maximum width 128 (102) µm, width of aperture 43 (34) µm, length of neck 1/3 of the total length, length of spines 41 µm.

Occurrence: Amazonas Basin, PETROBRAS 1-AM-1-AM well (Figs 1A, 4). Upper part of the Manacapuru Formation (Azevedo-Soares and Grahn 2005). Assemblage 7, see Fig. 13.

Ramochitina sp. sensu Grahn and Paris 1992
Plate VII, figs 7, 8

1992 *Gotlandochitina* sp. – Grahn and Paris, Plate 2, fig. 10

Discussion: A *Ramochitina* species with an elongated body and a cylindrical neck. The vesicle has 10 or more crests comprised of long simple spines. The neck widens slightly at the aperture. The vesicle wall between the spines is tuberculate.

Dimensions (three specimens measured): Total length 129–222 µm, maximum width 67 (54)–98 (78) µm, width of aperture 35 (28)–54 (43) µm, length of neck 1/2 of the total length, length of spines *Angochitina hemeri* 24 µm.

Occurrence: Amazonas Basin, shallow borehole SR 07 (Figs 2B, 3A, 8), outcrop locality Igarapé da Rainha. Pitinga Formation (Grahn and Paris 1992). Assemblages 3 and 4, see Fig. 12.

Subfamily Ancyrochitininae Paris 1981

Genus *Ancyrochitina* Eisenack 1955a

Ancyrochitina pitingaense n. sp.
Plate I, figs 15, 16, Plate II, fig. 1

2003 ?*Ancyrochitina* n. sp. A – Grahn, Plate 1, fig. 4

Derivation of name: Latin, *pitingaense*, referring to the Pitinga Formation, from where the holotype is described.

Diagnosis: An *Ancyrochitina* species with 7–8 simple, wide, and tapering appendages at the basal margin, and similar shaped spines on the neck near the aperture. The vesicle wall is covered with minute simple spines.

Holotype: Plate I, fig. 15. UERJ/DEPA SEM collection 25050

Type locality: Well SM 1015 (19.38–19,41 m).

Description: This species has an ovoid body and a cylindrical neck widening at the aperture. The vesicle wall is covered by randomly distributed minute and simple spines. At the basal margin there are seven to eight appendages with wide bases, and which taper towards their tips. The same number of similarly shaped spines occurs on the neck near the aperture. These are thinner and curve aborally, in contrast to the appendages that tend to project aperturally.

Dimensions (seven specimens measured): Total length 200–326 µm. Holotype 326 µm; maximum width 92 (74)–168 (134) µm. Holotype 148 (118) µm, width of aperture

53 (42)–80 (64) µm. Holotype 78 (62) µm, length of neck 1/2 of total length; length of appendages 82–120 µm. Holotype 109 µm, length of spines 51–87 µm. Holotype 87 µm.

Occurrence: Amazonas Basin, shallow boreholes SM 1015 and SM 1018 (Figs 1B, 9). Upper part of the Pitinga Formation. Assemblage 4, see Fig. 12. Doubtful specimens designated as *Ancyrochitina* n. sp. A were reported from the Copo Formation, Chaco-Paraná Basin, northeast Argentina (Grahn 2003).

Ancyrochitina cf. *A. brevis* Taugourdeau and Jekhowsky 1960
Plate I, figs 4, 5

1989 *Ancyrochitina fragilis brevis* – Quadros, p. 28–30, Plate 1
2005 *Ancyrochitina* cf. A. *brevis* – Azevedo-Soares and Grahn, Fig. 5:15, 17

Discussion: For a description of *Ancyrochitina* brevis see Jaglin and Paris (2002). *Ancyrochitina* cf. *A. brevis* differs in having much longer appendages than typical *A. brevis*, which has a maximum length of 40 µm.

Dimensions (12 specimens measured): Total length 176–229 µm, maximum width 68 (54)–121 (97) µm, width of aperture 34 (27)–88 (70) µm, length of neck 1/3–2/3 of the total length, length of appendages 56–122 µm.

Occurrence: Amazonas Basin, PETROBRAS 1-AM-1-AM well (Figs 1A, 4), shallow boreholes SM 2001, SM 2003, SM 2004, SM 2005, and SM 2006 (Figs 1B, 9). Upper part of the Pitinga and lower part of the Manacapuru formations (Quadros 1989, Azevedo-Soares and Grahn 2005). Assemblages 4, 5 and 7, see Fig. 13.

Ancyrochitina aff. *A. asterigis* Paris 1981
Plate I, fig. 3

2005 *Ancyrochitina* aff. *A. asterigis* – Azevedo-Soares and Grahn, Fig. 6:2

Discussion: For a description of *Ancyrochitina asterigis*, see Paris (1981). *Ancyrochitina* aff. *A. asterigis* differs in having thinner appendages, and less pronounced spiny ornamentation on the neck.

Dimensions (one specimen measured): Total length 212 µm, maximum width 112 (90) µm, width of aperture 82 (66) µm, length of neck 2/5 of the total length, length of appendices ≤ 91 µm.

Occurrence: Amazonas Basin, 1-AM-1-AM well (Figs 1A, 4). Uppermost part of Manacapuru Formation (Azevedo-Soares and Grahn 2005). Assemblage 7, see Fig. 13.

Ancyrochitina aff. *A. regularis* Taugourdeau and Jekhowsky 1960
Plate VI, fig. 2

Discussion: For a description of *Ancyrochitina regularis* see Jaglin and Paris (2002). *Ancyrochitina* cf. *A. regularis* differs in having a neck that widens at the aperture.

Dimensions (one specimen measured): Total length 134 µm, maximum width 69 (55) µm, width of aperture 47 (38) µm, length of neck 1/2 of the total length, length of appendices ≤ 34 µm.

Occurrence: Amazonas Basin, PETROBRAS 1-UI-2-AM well (Figs 2A, 11). Upper part of the Pitinga Formation. Assemblage 4, see Fig. 12.

Ancyrochitina aff. *A. tomentosa* Taugourdeau and Jekhowsky 1960
Plate I, fig. 13

1987 *Ancyrochitina tomentosa* – Boumendjel, p. 90, Plate 16, fig. 9
2005 *Ancyrochitina* aff. *A. tomentosa* – Azevedo-Soares and Grahn, Fig. 4:3

Discussion: *Ancyrochitina* aff. *A. tomentosa* has a conical body and a cylindrical neck. The vesicle wall is covered with randomly distributed minute and simple spines, which are bigger just above the flexure towards the aperture. The basal margin has eight to ten appendages that branch at their tips. Each of these branches is generally subdivided twice. *Ancyrochitina tomentosa* is a badly characterized species that has become a waste basket. *Ancyrochitina* aff. *A. tomentosa* is much bigger, and has a comparatively longer neck, than the specimens of *A. tomentosa* illustrated by Paris (1981).

Dimensions (11 specimens measured): Total length 133–222 µm, maximum width 65 (52)–124 (99) µm, width of aperture 45 (36)–113 (90) µm, length of neck 2/5–3/5 of the total length, length of appendages ≤ 75 µm; length of spines ≤ 33 µm.

Occurrence: Amazonas Basin, PETROBRAS 1-AM-1-AM, 1-NO-3-AM, and 1-UI-2-AM wells (Figs 1A, 2A, 4–5, 11), shallow boreholes SR 01, SR 07, and SR 10 (Figs 2B, 3A–B, 6, 8, 10). Pitinga Formation (Azevedo-Soares and Grahn 2005). Assemblages 3 and 5, see Fig. 12. Boumendjel (1987) described similar specimens from the Late Lochkovian part of the Mehaiguène Formation, Oued Mya Basin, Algerian Sahara.

Ancyrochitina ex. gr. *ancyrea* (Eisenack 1931)
Plate I, fig. 2

1967 Tipo 13 – Lange, Plate 2, fig. 13.
2003 *Ancyrochitina* ex. gr. *ancyrea* – Grahn and Melo, p. 382, Plate 2, figs 11, 12

Discussion: This chitinozoan species was discussed by Grahn and Melo (2003). They are more slender than *A. ancyrea* s.s.

Dimensions (two specimens measured): Total length 163–263 µm, maximum width 100 (80)–127 (102) µm, width of aperture 48 (38)–55 (44) µm, length of neck 1/2–2/5 of the total length, length of appendages ≤ 61 µm.

Occurrence: Amazonas Basin, PETROBRAS 1-AM-1-AM and 2-MN-1-AM wells (Figs 1A, 4, 9), shallow borehole SM 1018 (Figs 1B, 5). Pitinga (Lange 1967, Grahn and Melo 2003) and lowermost part of the Manacapuru formations. Assemblages 3–5, see Fig. 12.

Ancyrochitina ex. gr. *floris* Jaglin 1986
Plate I, fig. 7

2003 *Ancyrochitina* ex. gr. *floris* – Grahn and Melo, p. 382, Plate 2, figs 13–14
2005 *Ancyrochitina* ex. gr. *floris* – Azevedo-Soares and Grahn, Fig. 4:4

Discussion: These chitinozoans were discussed by Grahn and Melo (2003). In contrast to *A. floris* they have a glabrous body.

Dimensions (one specimen measured): Total length 155 µm, maximum width 129 (103) µm; width of aperture 51 (41) µm, length of neck 2/5 of the total length, length of appendages ≤ 56 µm.

Occurrence: Amazonas Basin, PETROBRAS 1-AM-1-AM well (Figs 1A, 4). Uppermost part of the Pitinga (Grahn and Melo 2003, Azevedo-Soares and Grahn 2005) and possibly lowermost part of the Manacapuru formations. Assemblages 4 and 5, see Fig. 13.

Ancyrochitina sp. A *sensu* Grahn and Paris 1992
Plate VI, fig. 3

1971 *Plectochitina saharica* – Costa, p. 59, Plate 11, figs 3–5
1971 *Sphaerochitina collinsoni* – Costa, p. 66-67, Plate 12, fig. 2
1971 *Cyathochitina campanulaeformis* – Costa, p. 77–79, Plate 15, figs 4–5
1992 *Ancyrochitina* sp. A – Grahn and Paris, Plate 1, fig. 5

Discussion: *Ancyrochitina* species with conical body and cylindrical neck. The basal margin is well-rounded and has ten long appendages. The vesicle wall is covered with randomly distributed simple spines. Flexure is pronounced.

Dimensions (13 specimens measured): Total length 109–184 µm, maximum width 74 (59)–113 (90) µm, width of aperture 26 (21)–52 (42) µm, length of neck 2/5–3/5 of the total length, length of appendices ≤ 80 µm.

Occurrence: Amazonas Basin, PETROBRAS 1-UI-2-AM well (Figs 2A, 11), shallow boreholes SR 01, SR 03, SR 07, and SR 10 (Figs 2B, 3A–C, 6–8, 10). Lower part of the Pitinga Formation. Assemblage 3 , see Fig. 12.

Ancyrochitina n. sp. A
Plate II, fig. 2

1974 *Ancyrochitina ancyrea* – Cramer, Díez and Cuerda, Fig. 3, Figs 5a–g

Discussion: This species has an ovoid body and a cylindrical neck. Six thick appendages with basket-like structures at the tips, and a corresponding number of similarly-shaped spines on the neck. The vesicle wall is covered with randomly distributed minute and simple spines. *Ancyrochitina* n. sp. A differs from *Ancyrochitina pitingaense* n. sp. in having thinner appendages and spines provided with basket-like structures.

Dimensions (two specimens measured): Total length 159–203 µm, maximum width 85 (68)–103 (82) µm, width of aperture 44 (35)–50 (40) µm, length of neck 1/2 of the total length, length of appendices ≤ 97 µm, length of spines ≤ 78 µm.

Occurrence: Amazonas Basin, outcrop locality AM 74 (Figs 1B, 9). Upper part of the Pitinga Formation. Assemblage 5, see Fig. 13. Cramer et al. (1974) documented this species as a Bolivian variant of *A. ancyrea* from Ludlow? beds of the Kirusillas Formation at Cochabamba, Bolivia.

Ancyrochitina n. sp. B
Plate II, fig. 3

Discussion: An *Ancyrochitina* species with an ovoid body and a cylindrical neck. The basal margin has eight simple, tapering appendages that project anteaperturally. Minute simple spines randomly cover the vesicle wall.

Dimensions (five specimens measured): Total length 180–230 µm, maximum width 90 (72)–111 (89) µm, width of aperture 52 (42)–55 (44) µm, length of neck 1/2 of the total length, length of appendages ≤ 70 µm, length of spines ≤ 63 µm.

Occurrence: Amazonas Basin, PETROBRAS 1-AM-1-AM well (Figs 1A, 4), outcrop locality AM 75 (Figs 1B, 9). Pitinga Formation. Assemblages 3 and 5, see Fig. 12.

Ancyrochitina n. sp. C
Plate II, fig. 4

Discussion: This species has an ovoid body and a cylindrical neck. The vesicle wall is covered with minute and simple spines. At the basal margin occur six simple, tapering appendages that branch at their tips. On the neck there are four similarly-shaped spines.

Dimensions (one specimen measured): Total length 243 µm, maximum width 100 (80) µm, width of aperture 55 (44) µm, length of neck 2/5 of the total length, length of appendages ≤ 50 µm.

Occurrence: Amazonas Basin, shallow borehole SM 2003 (Figs 1B, 9). Uppermost part of the Manacapuru Formation. Assemblage 7, see Fig. 13.

Ancyrochitina n. sp. D
Plate II, fig. 5

Discussion: *Ancyrochitina* n. sp. D has an ovoid body and a cylindrical neck. The vesicle wall is covered by randomly distributed minute and simple spines that increase in size on the neck. The basal margin has six simple appendages that taper towards the tips and are curved aperturally.

Dimensions (one specimen measured): Total length 211 µm, maximum width 104 (83) µm, width of aperture 85 (68) µm, length of neck 2/3 of the total length, length of appendages ≤ 74 µm.

Occurrence: Amazonas Basin, PETROBRAS 1-AM-1-AM well (Figs 1A, 4). Uppermost part of the Manacapuru Formation. Assemblage 7, see Fig. 13.

Ancyrochitina n. sp. E
Plate II, fig. 6

Discussion: An *Ancyrochitina* species with an ovoid body and flared neck. The vesicle wall is covered with randomly distributed minute and simple spines. The basal margin has 10–12 simple, long, tapering appendages that are curved antiaperturally.

Dimensions (one specimen measured): Total length 211 µm, maximum width 104 (83) µm, width of aperture 85 (68) µm, length of neck 2/3 of the total length, length of appendages ≤ 74 µm.

Occurrence: Amazonas Basin, PETROBRAS 1-AM-1-AM well (Figs 1A, 4). Uppermost part of the Manacapuru Formation. Assemblage 7, see Fig. 13.

Genus *Plectochitina* Cramer 1964

Plectochitina n. sp. A
Plate IV, fig. 3

2005 *Plectochitina* n. sp. A – Azevedo-Soares and Grahn, Fig. 6:15

Discussion: This very characteristic *Plectochitina* species has a short conical body and a flared neck. The vesicle wall is glabrous. The basal age has eight massive appendages that branch at their tips. Each of these branches may be further subdivided into thinner branches. The total number of these thinner branches has not been recorded in the study material.

Dimensions (three specimens measured): Total length 213–233 µm, maximum width 117 (94)–133 (106) µm, width of aperture 73 (58)–92 (74) µm, length of neck 2/3–1/2 of the total length, length of appendages ≤ 125 µm.

Occurrence: Amazonas Basin, shallow boreholes SM 2003 and SM 2004 (Figs 1B, 9). Uppermost part of the Manacapuru Formation (Azevedo-Soares and Grahn 2005). Assemblage 7, see Fig. 13.

Chitinozoan biostratigraphy

Chitinozoans from the upper part of the Autas-Mirim Formation were described by Grahn (1992b), who recognized a characteristic late Ashgill (Rawtheyan) assemblage in the PETROBRAS 1-AM-1-AM well at level 2091 m that includes *Armoricochitina nigerica*? (Bouché 1965), *Lagenochitina prussica* Eisenack 1931, and *Tanuchitina anticostiensis* (Achab 1977) among others. The Nhamundá Formation is indirectly dated by the interfingering and overlying shales of the lower part of the Pitinga Formation. The chitinozoan biostratigraphy of the Pitinga and Manacapuru formations have been discussed by Grahn (1992a), Grahn and Paris (1992), and Grahn and Melo (2003). In the present data set of seven chitinozoan assemblages are distinguished (Figs 12, 13), i.e. 1–3 (lower Pitinga Formation), 4 (upper Pitinga Formation), 5 (at the transition between the Pitinga and Manacapuru formations), 6 (lower-middle Manacapuru Formation), and 7 (upper Manacapuru Formation). Reworking is very common in the Lower Silurian beds due to three glacial events during that time (Grahn and Caputo 1992). The assemblages are described in ascending stratrigraphic order below.

Assemblage 1

Assemblage 1 (Fig. 12) is of Late Rhuddanian–Early Aeronian age. The appearance of *Spinachitin*a species (i.e. *Spinachitina* n. sp. A) is characteristic of the early Aeronian, and in the Lower Silurian strata of the intracratonic basins of Brazil and Paraguay this genus does not range into the Telychian (Grahn et al. 2000, Grahn et al. 2005). Another diagnostic chitinozoan species in the Amazonas Basin is *Euconochitina iklaensis*, a species ranging from the Upper Rhuddanian to Aeronian (Verniers et al. 1995). *Ancyrochitina ancyrea* and the *Cyathochitina* species present have long ranges, and are known from the Early Llandovery elsewhere.

Assemblage 2

Assemblage 2 (Fig. 12) is of the latest Aeronian–Early Telychian age. In the Paraná Basin many species that appear in the uppermost Aeronian range into the Upper Telychian (Grahn et al. 2000), and this distribution pattern is also true for the Amazonas Basin. Assemblage 2 is well developed in the Parnaíba Basin (Grahn et al. 2005). The majority of the species in this assemblage probably represents an Early Telychian age. The absence of typical and common species for the Late Telychian–Early Sheinwoodian, and the absence of *Spinachitina* species, are characteristic of the assemblage.

Assemblage 3

Assemblage 3 (Fig. 12) is of Late Telychian–Early Sheinwoodian age. The assemblage is well developed in the Amazonas and Paraná basins. Diagnostic species in the Amazonas Basin include *Angochitina* sp. A *sensu* Grahn and Paris 1992, *Belonechitina*? *plumula* n. sp., *Conochitina acuminata, Desmochitina densa, Euconochitina cruzi, Euconochitina patula, Euconochitina sulcata, Linochitina penequadrata* n. sp., *Margachitina margaritana, Pterochitina deichaii*, and *Salopochitina monterrosae*. This chitinozoan assemblage characterizes the upper lower part of the Pitinga Formation in the Amazonas Basin, and the up-

per part of the Vargas Peña Formation in the Paraná Basin (Grahn et al. 2000).

Assemblage 4

Assemblage 4 (Figs 12 and13) is of Ludlow age, the only other definite report of which is from the upper part of the Pitinga Formation in the Amazonas Basin (Azevedo-Soares and Grahn 2005). Grahn and Melo (2003) reported Upper Ludlow beds from possibly lowermost Manacapuru Formation along the Urubu River. Species like *Ancyrochitina pitingaense* n. sp., *Ramochitina illiziensis, Salopochitina* aff. *S. monterrosae, Tanuchitina elenitae*, and *Tanuchitina* aff. *T. cylindrica* characterize this assemblage. Most of the species present in this assemblage range into lower Pridoli beds which contain Assemblage 5. Assemblage A of Grahn and Melo (2003) corresponds to the upper part of Assemblage 4 in this study (see Figs 12 and 13).

Assemblage 5

Assemblage 5 (Figs 12 and 13) is of early Pridoli age. Beds of this age are known from the Amazonas Basin (Azevedo-Soares and Grahn 2005) and probably from the Solimões Basin (Grahn et al. 2003) as well. Many chitinozoan species in this zone range from Late Ludlow. The species restricted to this assemblage in the Amazonas Basin include *Angochitina* n. sp. aff. *A. cyrenaicensis, Angochitina*? sp. *sensu* Grahn and Paris 1992, *Fungochitina kosovensis, Ramochitina bjornsundquisti, Rhabdochitina conocephala*?, *Saharochitina gomphos, Urochitina* n. sp. A, and *Vinnalochitina corinnae*. These species are representative of the uppermost Pitinga and lowermost Manacapuru formations in the Amazonas Basin (Azevedo-Soares and Grahn 2005). Assemblage 5 corresponds to Assemblage A of Azevedo-Soares and Grahn (2005) and Assemblage B of Grahn and Melo (2003, see Fig. 13).

Assemblage 6

Assemblage 6 (Fig. 13) is an earliest Lochkovian assemblage, which so far has only been reported from the Amazonas Basin. The presence of *Margachitina catenaria* confirms the Lochkovian age, and its stratigraphic position above Lower Pridoli beds, and below typical Lower Lochkovian beds, does not contradict, a lowermost Lochkovian correlation. Characteristic species are *Angochitina* cf. *Sphaerochitina densibaculata* and *Ramochitina* n. sp. cf. *R. devonica* (cf. Azevedo-Soares and Grahn 2005). The Silurian-Devonian boundary was discussed in detail by Azevedo-Soares and Grahn (2005), who identified a gap between Lower Pridoli and Lower Lochkovian strata, and the assemblage corresponds to their Assemblage B (see Fig. 13).

Assemblage 7

Assemblage 7 (Fig. 13) is of the Early Lochkovian age, and is present in the Solimões and Amazonas basins (Grahn and Melo 2003; Grahn et al. 2003). Characteristic species include *Ancyrochitina* aff. *A. asterigis, Ancyrochitina cantabrica, Ancyrochitina ollivierae, Angochitina filosa, Angochitina strigosa, Cingulochitina ervensis, Eisenackitina* cf. *E. bohemica, Plectochitina* n. sp. A, and *Pterochitina megavelata*. Assemblage 7 corresponds to Assemblage C by Azevedo-Soares and Grahn (2005) and Grahn and Melo (2003, see Fig. 13).

Concluding remarks

Chitinozoans from the Trombetas Group documented herein have been compared with coeval faunas from other parts of Gondwana, to which they have a pronounced affinity. The PETROBRAS 1-AM-1-AM well has been selected as a reference section for the Trombetas Group chitinozoan succession. Seven Siluro-Devonian chitinozoan assemblages can be defined from the Late Rhuddanian–Early Aeronian (1), latest Aeronian–Early Telychian (2), Late Telychian–Early Sheinwoodian (3), Ludlow (4), Early Pridoli (5), earliest Lochkovian (6), and Early Lochkovian (7). Assemblages 4, 5, and 7 were also defined in the Urubu area in the western part of the Amazonas Basin although designated by different schemas (see Figs 12 and 13; Grahn and Melo 2003). These assemblages have also been distinguished in coeval rocks from other intracratonic basins in Brazil and Paraguay.

The basal Autas-Mirim Formation is Late Ordovician (Caradoc? – Ashgill; Grahn 1992a, b), and the overlying Nhamundá Formation is indirectly dated by the interfingering and overlying shales of the lower part of the Pitinga Formation, which is Llandovery–early Wenlock in its type area. It consists of three transgressive cycles (Late Rhuddanian–Early Aeronian, latest Aeronian–Early Telychian, and Late Telychian–Early Sheinwoodian). The upper part of the Pitinga Formation is dated as Ludlow–Early Pridoli, and is well developed in shallow borings in the Trombetas area. The lower part of the Manacapuru Formation is of Early Pridoli age in the Trombetas area, but may be as old as Late Ludlow in the Urubu area (Grahn and Melo 2003). A badly characterized earliest Lochkovian interval occurs transgressively over Lower Pridoli strata in the Trombetas area. A characteristic Early Lochkovian chitinozoan assemblage is present in the uppermost part of the Manacapuru Formation, and in the lower part of the Jatapu Member of the Maecuru Formation (Urupadi Group). Of the 104 species present, 51 are left in open nomenclature and only three species, *Ancyrochitina pitingaense*, *Belonechitina*? *plumula* and *Linochitina penequadrata*, are described as new.

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Plate I. Chitinozoans from the Trombetas Group. Scale bars represent 100 µm.
1 – *Ancyrochitina ancyrea* (Eisenack 1931), well 1-AM-1-AM, cuttings 1752–1755 m. 2 – *Ancyrochitina* ex. gr. *ancyrea* (Eisenack 1931), well 2-MN-1-AM, core 42 (1253.30–1252.40 m). 3 – *Ancyrochitina* aff. *A. asterigis* Paris 1981, well 1-AM-1-AM, core 37 (1522.00–1524.30 m). 4 – *Ancyrochitina* cf. *A. brevis* (Taugourdeau and Jekhowsky 1960), well SM 2001 (9.86–9.90 m). 5 – *Ancyrochitina* cf. *A. brevis* (Taugourdeau and Jekhowsky 1960), well SM 2004 (45.08–45.12 m). 6 – *Ancyrochitina cantabrica* Cramer and Díez 1978, well SM 2004 (38.36–38.40 m). 7 – *Ancyrochitina* ex. gr. *floris* Jaglin 1986, well 1-AM-1-AM, core 42 (1598.40–1599.30 m). 8 – *Ancyrochitina fragilis* Eisenack 1955, outcrop AM 85. 9 – *Ancyrochitina ollivierae* Boumendjel 2002, well 1-AM-1-AM, core 37 (1522.00–1524.30 m). 10 – *Ancyrochitina primitiva* Eisenack 1955, well 2-SL-1-AM, cuttings 591–606 m. 11 – *Ancyrochitina regularis* Taugourdeau and Jekhowsky 1960, well 1-AM-1-AM, cuttings 1630–1633 m. 12 – *Ancyrochitina regularis* Taugourdeau and Jekhowsky 1960, well 1-AM-1-AM, cuttings 1644–1647 m. 13 – *Ancyrochitina* aff. *A. tomentosa* (Taugourdeau and Jekhowsky 1960), well 1-AM-1-AM, core 37 (1522.00–1524.30 m). 14 – *Ramochitina* n. sp. A, well 1-AM-1-AM, core 37 (1522.00–1524.30 m). 15 – *Ancyrochitina pitingaense* n. sp., holotype, well SM 1048 (22.08–22,10 m). 16 – *Ancyrochitina pitingaense* n. sp., well SM 1048 (22.08–22.10 m).

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Plate II. Chitinozoans from the Trombetas Group. Scale bars represent 100 µm.
1 – *Ancyrochitina pitingaense* n. sp., well SM 1048 (22.08–22.10 m). 2 – *Ancyrochitina* sp. A, outcrop AM 74. 3 – *Ancyrochitina* sp. B, well 1-AM-1-AM, cuttings 1677–1680 m. 4 – *Ancyrochitina* sp. C, outcrop AM 75. 5 – *Ancyrochitina* sp. D, well SM 2003 (32.16–32.19 m). 6 – *Ancyrochitina* sp. E, well 1-AM-1-AM, core 37 (1522.00–1524.30 m). 7 – *Angochitina* n. sp. aff. *A. cyrenaicensis* Paris 1988, IGR, well 1-AM-1-AM, core 46 (1607.00–1613.00 m). 8 – *Angochitina echinata* Eisenack 1931, well 1-AM-1-AM, core 46 (1607.00–1613.00 m). 9 – *Angochitina* sp. A *sensu* Grahn and Paris 1992, well SR 03 (54.13–54.15 m). 10 – *Angochitina filosa* Eisenack 1955, well SM 2003 (32.16–32.19 m). 11 – *Angochitina longicollis* Eisenack 1959, well 1-AM-1-AM, cuttings 1674–1677 m. 12 – *Angochitina strigosa* Boumendjel 2002, well SM 2005 (23.02-23.06 m). 13 – *Angochitina* sp. A sensu Grahn and Paris 1992, IGR, well 1-MU-3-AM, core 17 (1386.00–1388.00 m). 14 – *Angochitina* cf. *Sphaerochitina densibaculata* Volkheimer et al. 1986, well 1-AM-1-AM, cuttings 1536 m. 15 – *Angochitina* sp. B, well 1-AM-1-AM, core 35 (1503.80–1508.80 m). 16 – *Angochitina* sp. C, well 1-AM-1-AM, core 37 (1522.00–1524.30 m). 17 – *Angochitina* sp. D, well 1-AM-1-AM, core 37 (1522.00–1524.30 m). 18 – *Angochitina*? sp. sensu Grahn and Paris 1992, IGR, well 1-AM-1-AM, core 42 (1598.40–1599.30 m). 19 – *Angochitina*? sp. sensu Grahn and Paris 1992, well 1-AM-1-AM, core 42 (1598.40–1599.30 m). 20 – *Cingulochitina convexa* (Laufeld 1974), outcrop AM 76. 21 – *Cingulochitina* aff. *C. convexa* (Laufeld 1974), well 1-AM-1-AM, cuttings 1749–1752 m.

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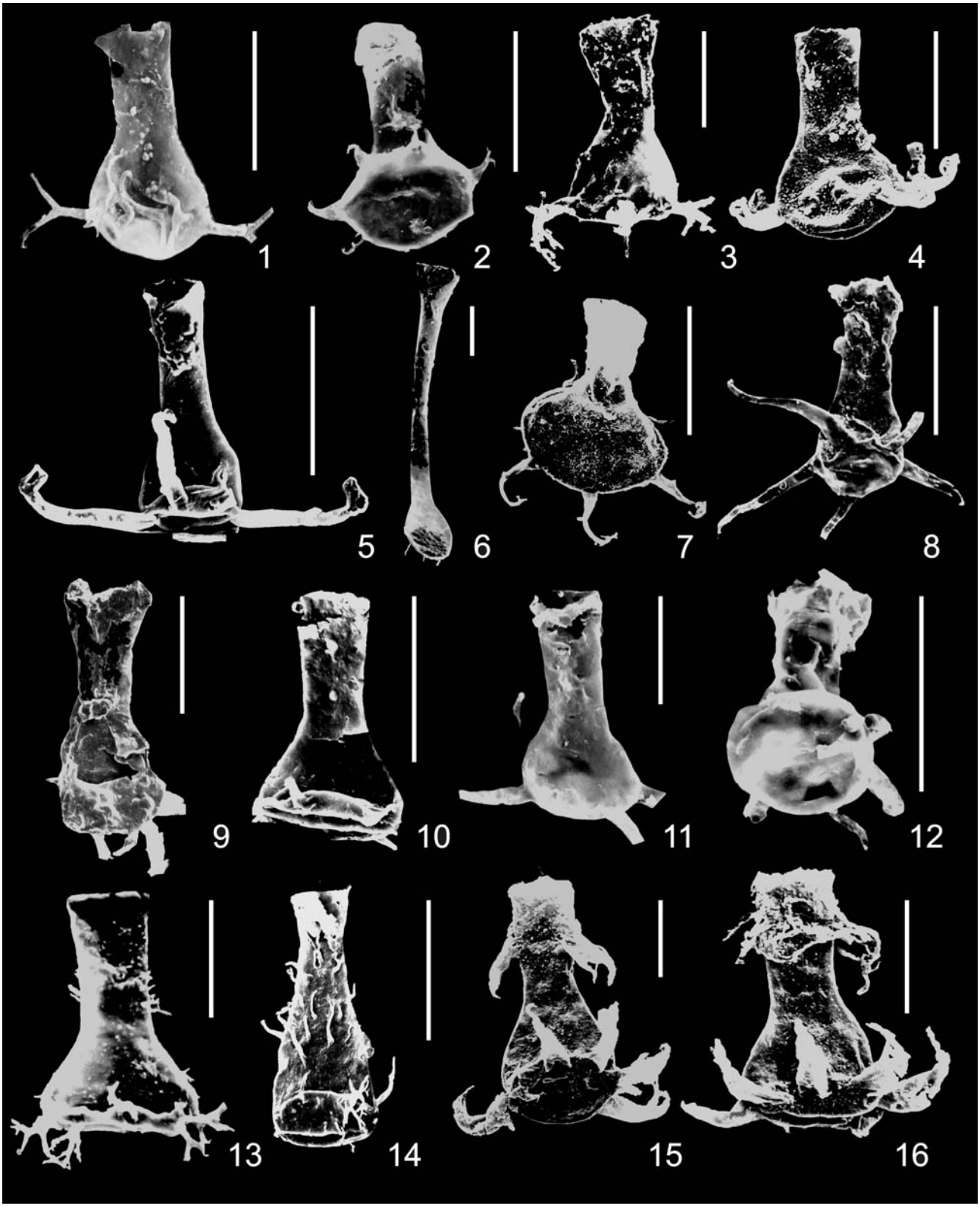
Plate III. Chitinozoans from the Trombetas Group. Scale bars represent 100 µm.
1 – *Cingulochitina convexa* (Laufeld 1974), outcrop AM 75. 2 – *Cingulochitina ervensis* Paris (in Babin et al. 1979), well 1-AM-1-AM, core 35 (1503.80–1508.80 m). 3 – *Cingulochitina* aff. *C. ervensis* Paris (in Babin et al. 1979), well 1-AM-1-AM, core 45 (1602.30–1602.50 m). 4 – *Cingulochitina serrata* (Taugourdeau and Jekhowsky 1960), well 1-AM-1-AM, core 46 (1607.00–1613.00 m). 5 – *Cingulochitina* aff. *C. serrata* (Taugourdeau and Jekhowsky 1960), well 1-AM-1-AM, cuttings 1749–1752 m. 6 – *Cingulochitina wronai* Paris 1984, well SM 1018 (13.57–13.59 m). 7 – *Cingulochitina ervensis* Paris (in Babin et al. 1979), well SM 2004 (45.08–45.12 m). 8 – *Conochitina acuminata* Eisenack 1964, well 2-NO-1-AM, core 14 (1253.60–1256.30 m). 9 – *Conochitina gordonensis* Cramer 1964, well 1-AM-1-AM, core 42 (1598.40–1599.30 m). 10 – *Conochitina tuba* Eisenack 1964, outcrop AM 75. 11 – *Conochitina pachycephala* Eisenack 1964, well 1-AM-1-AM, core 46 (1607.00–1613.00 m). 12 – *Conochitina pachycephala* Eisenack 1964, well 1-AM-1-AM, cuttings 1644–1647 m. 13 – *Conochitina proboscifera* Eisenack 1955, well SM 1017 (21.92–21.97 m). 14 – *Cyathochitina caputoi* Costa 1971, well 1-NO-3-AM, core 29 (3346.20–3347.40 m). 15 – *Cyathochitina* sp. B Paris 1981, well 1-AM-1-AM, cuttings 1749–1752 m. 16 – *Desmochitina densa* Laufeld 1974, well SM 1018 (21.60–21.64 m). 17 – *Desmochitina densa* Laufeld 1974, well 2-NO-1-AM, core 14 (1253.60–1256.30 m). 18 – *Cingulochitina cylindrica* (Taugourdeau and Jekhowsky 1960), well 1-MU-3-AM, core 17 (1386.00–1388.00 m). 19 – *Eisenackitina* cf. *E. bohemica* Eisenack 1934, outcrop Pt.10 (Urubu River; see Grahn and Melo 2003). 20 – *Eisenackitina granulata* Cramer 1964, well 1-AM-1-AM, core 46 (1607.00–1613.00 m). 21 – *Euconochitina iklaensis* Nestor 1984, well SM 1017 (21.92–21.94 m). 22 – *Euconochitina iklaensis* Nestor 1984, well SM 1017 (21.92–21.94 m). 23 – *Euconochitina patula* (Costa 1971), well 1-AM-1-AM, cuttings 1674–1677 m. 24 – *Euconochitina sulcata* (Costa 1971), well 1-NO-3-AM, core 28 (3291.20–3293.00 m). 25 – *Fungochitina kosovensis* Paris 1981, IGR, well 1-AM-1-AM, core 46 (1607.00–1613.00 m). 26 – *Fungochitina* sp. A, well SM 1017 (21.91–21.94 m). 27 – *Linochitina* ex. gr. *erratica* (Eisenack 1931), well SM 1018 (13.09–13.13 m). 28 – *Margachitina catenaria* Obut 1973, well SM 2005 (32.02–32.05 m).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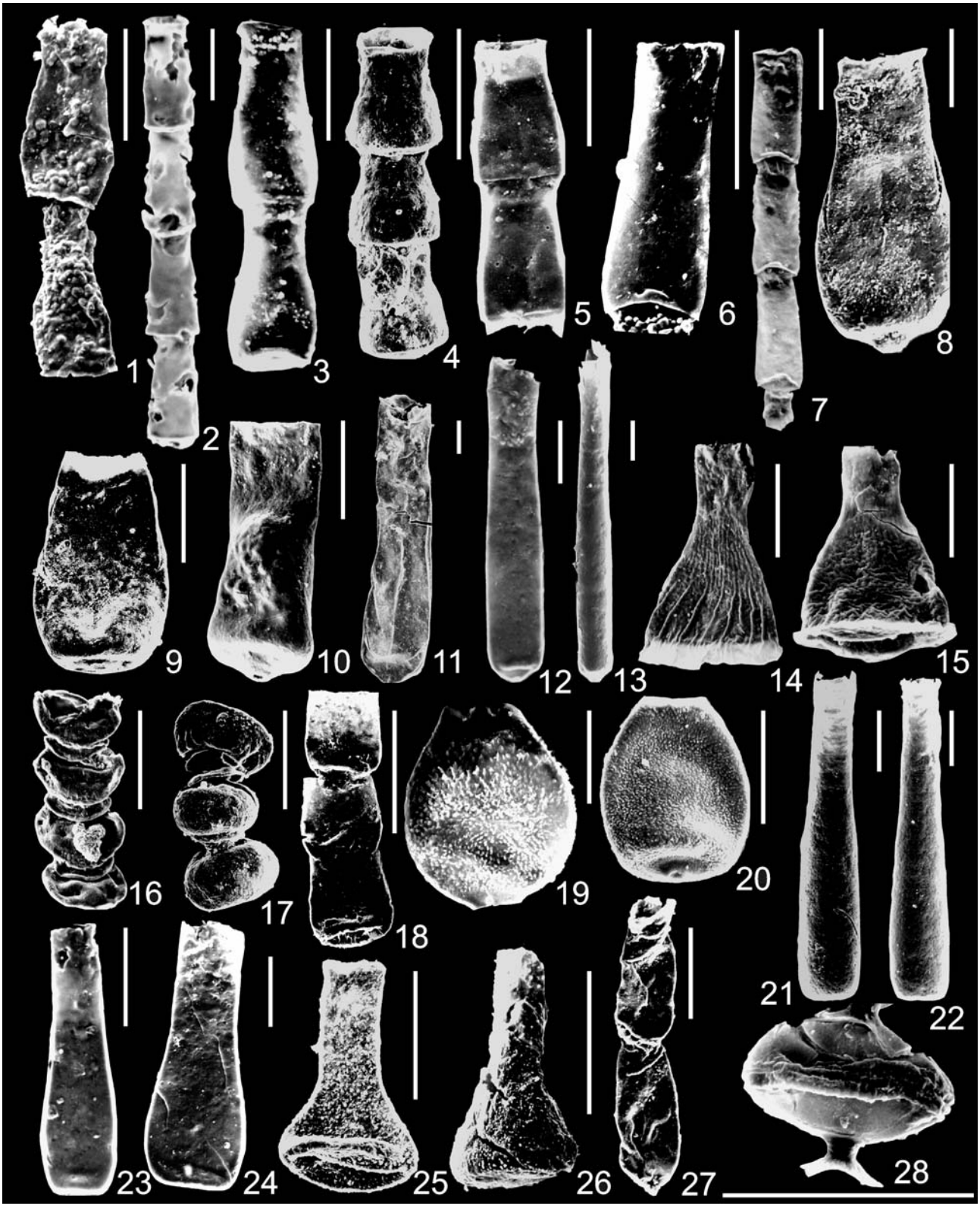
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Plate IV. Chitinozoans from the Trombetas Group. Scale bars represent 100 μm.
1 – *Margachitina margaritana* Eisenack 1968, well 1-AM-1-AM, cuttings 1746–1749 m. 2 – *Margachitina* aff. *M. saretensis* Boumendjel 2002, well SM 1015 (37.45–37.50 m). 3 – *Plectochitina* n. sp. A, well SM 2003 (32.16–32.19 m). 4 – *Pogonochitina djalmai* (Sommer and van Boekel 1965), IGR, outcrop Igarapé da Rainha 4-65-68. 5 – *Pogonochitina djalmai* (Sommer and van Boekel 1965), outcrop AM 76. 6 – *Pogonochitina* cf. *P. djalmai* (Sommer and van Boekel 1965), well 1-MU-3-AM, core 18 (1388.00–1389.00 m). 7 – *Pogonochitina inornata* (Costa 1971), outcrop AM 76. 8 – *Pterochitina megavelata* Boumendjel 2002, well SM 2004 (38.36–38.40 m). 9 – *Pterochitina perivelata* (Eisenack 1937), IGR, well 1-AM-1-AM, core 46 (1607.00–1613.00 m). 10 – *Ramochitina bjornsundquisti* Grahn and Melo 2003, IGR, well 1-AM-1-AM, core 42 (1598.40–1599.30 m). 11 – *Ramochitina* n. sp. cf. *R. devonica* Eisenack 1955, well 1-AM-1-AM, cuttings 1533–1536 m. 12 – *Rhabdochitina*? *conocephala* Eisenack 1938, well SM 1018 (9.48–9.51 m). 13 – *Saharochitina gomphos* Grahn and Melo 2003, well 1-AM-1-AM, cuttings 1677–1680 m (contamination).14 – *Salopochitina monterrosae* (Cramer 1969), well 1-AM-1-AM, cuttings 1746–1749 m. 15 – *Salopochitina* aff. *S. monterrosae* (Cramer 1969), contamination, well SM 1018 (28.53–28.56 m). 16 – *Spinachitina* n. sp. A, well SM 1017 (21.92–21.97 m). 17 – *Sphaerochitina palestinaense* Grahn et al. 2005, well 1-NO-3-AM, core 29 (3346.20–3347.40 m). 18 – *Sphaerochitina palestinaense* Grahn et al. 2005, well SM 1015 (47.73–47.77 m). 19 – *Spinachitina tianguaense* Grahn and Melo 2003, well SM 1047 (1394.70–1347.20 m). 20 – *Tanuchitina* aff. *T. cylindrica* (Taugourdeau and Jekhowsky 1960) *sensu* Boumendjel 1987, well SM 1015 (10.13–10.16 m). 21 – *Tanuchitina elenitae* Cramer 1964, well SM 1048 (13.89–13.92 m). 22 – *Urochitina* n. sp. A, outcrop AM 75. 23 – *Urochitina* n. sp. A, outcrop AM 75. 24 – *Vinnalochitina corinnae* (Jaglin 1986), outcrop AM 74.

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Plate V. Chitinozoans from the Trombetas Group. Scale bars represent 100 μm.
1 – *Ancyrochitina primitiva* Eisenack 1964, well SM 1048 (22.08–22.10 m). 2 – Angochitina sp. aff. A. mourai *sensu* Schweineberg 1987, well SM 1015 (10.13–10.16 m). 3 – *Belonechitina* sp. A, well SM 1015 (11.32–11.35 m). 4 – *Belonechitina* sp. A, well 1-CM-2-PA, core 44 (952.00–955.10 m). 5 – *Bursachitina wilhelmi* (Costa 1970), well 2-MU-1-AM, core 28 (1394.70–1397.20 m). 6 – *Bursachitina wilhelmi* (Costa 1970), well SM 1015 (37.45–37.50 m). 7 – *Cyathochitina campanulaeformis* (Eisenack 1931), well 1047 (17.53–17.57 m). 8 – *Conochitina elongata* (Taugourdeau and Jekhowsky 1960), well 1-AM-1-AM, cuttings 1677–1680 m. 9 – *Conochitina edjelensis* (Taugourdeau and Jekhowsky 1960), well 1-AM-1-AM, cuttings 1647–1650 m. 10 – *Pterochitina* sp. A, well SM 1017 (21.92–21.94 m). 11 – *Pterochitina* sp. A, well SM 1047 (15.80–15.89 m). 12 – *Spinachitina* n. sp. A, well SM 1017 (21.92–21.97 m). 13 – *Belonechitina* sp. B, well 1-CM-2-PA, core 44 (952.00–955.10 m). 14 – *Conochitina edjelensis* (Taugourdeau and Jekhowsky 1960), well 1-NO-3-AM, core 29 (3346.20–3347.40 m). 15 – *Conochitina* cf. *C. tuba* Eisenack 1932, well 1-AM-1-AM, cuttings 1647–1650 m. 16 – *Euconochitina cruzi* (Costa 1970), IGR, outcrop Igarapé da Rainha 4-65-68. 17 – *Linochitina* ex. gr. *erratica* (Eisenack 1931), well 1-NO-3-AM, core 29 (3346.20–3347.40 m).

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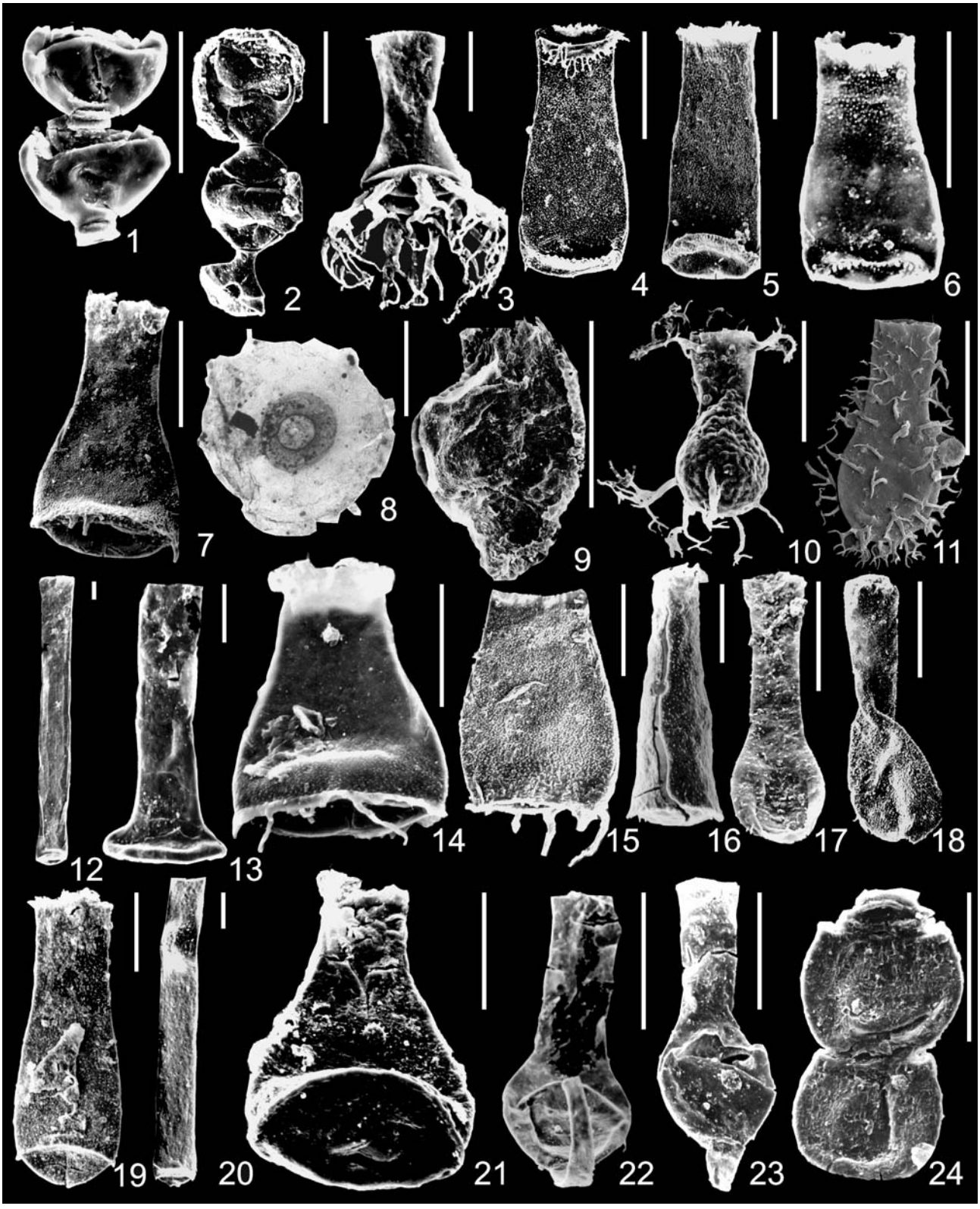
Plate VI. Chitinozoans from the Trombetas Group. Scale bars represent 100 μm.
1 – *Ancyrochitina* aff. *A. tomentosa* (Taugourdeau and Jekhowsky 1960), well SR 07 (46.45–46.46 m). 2 – *Ancyrochitina* aff. *A. regularis* (Taugourdeau and Jekhowsky 1960), well 1-UI-2-AM, core 9 (774.5 m). 3 – *Ancyrochitina* sp. A sensu Grahn and Paris 1992, well SR 03 (66.66–66.68 m). 4 – *Angochitina elongata* Eisenack 1931, well 1-UI-2-AM, core 10 (780.5 m). 5 – *Angochitina* cf. *A.* elongata Eisenack 1931, well SR 10 (62.79–62.81 m). 6 – *Angochitina* cf. *A. echinata* Eisenack 1931, IGR, outcrop Igarapé da Rainha 4-65-68. 7 – *Angochitina* cf. *A. echinata* Eisenack 1931, well SR 07 (44.26–44.27 m). 8 – *Belonechitina*? *plumula* n. sp., holotype, well SR 10 (64.10–64.12 m). 9 – *Belonechitina*? *plumula* n. sp., well SR 07 (47.51–47.52 m). 10 – *Belonechitina*? *plumula* n. sp., well SR 07 (34.13–34.14 m). 11 – *Belonechitina*? *plumula* n. sp., well SR 07 (37.70–37.71 m). 12 – *Conochitina* cf. *C. acuminata* Eisenack 1959, well SR 07 (34.13–34.14 m). 13 – *Cyathochitina* sp. B, IGR, two specimens in lateral view, outcrop Igarapé Ipiranga 4-65-82. 14 – *Euconochitina* sp. A, well SR 10 (62.79–62.81 m). 15 – *Euconochitina* sp. A, well SR 07 (44.26–44.27 m). 16 – *Lagenochitina* aff. *L. navicula* Taugourdeau and Jekhowsky 1960, IGR, three specimens in lateral view, outcrop Igarapé da Rainha 4-65-68. 17 – *Lagenochitina* aff. *L. navicula* Taugourdeau and Jekhowsky 1960, outcrop Igarapé da Rainha 4-65-68. 18 – *Linochitina penequadrata* n. sp., the lower specimen is the holotype, well SR 01 (95.54–95.56 m).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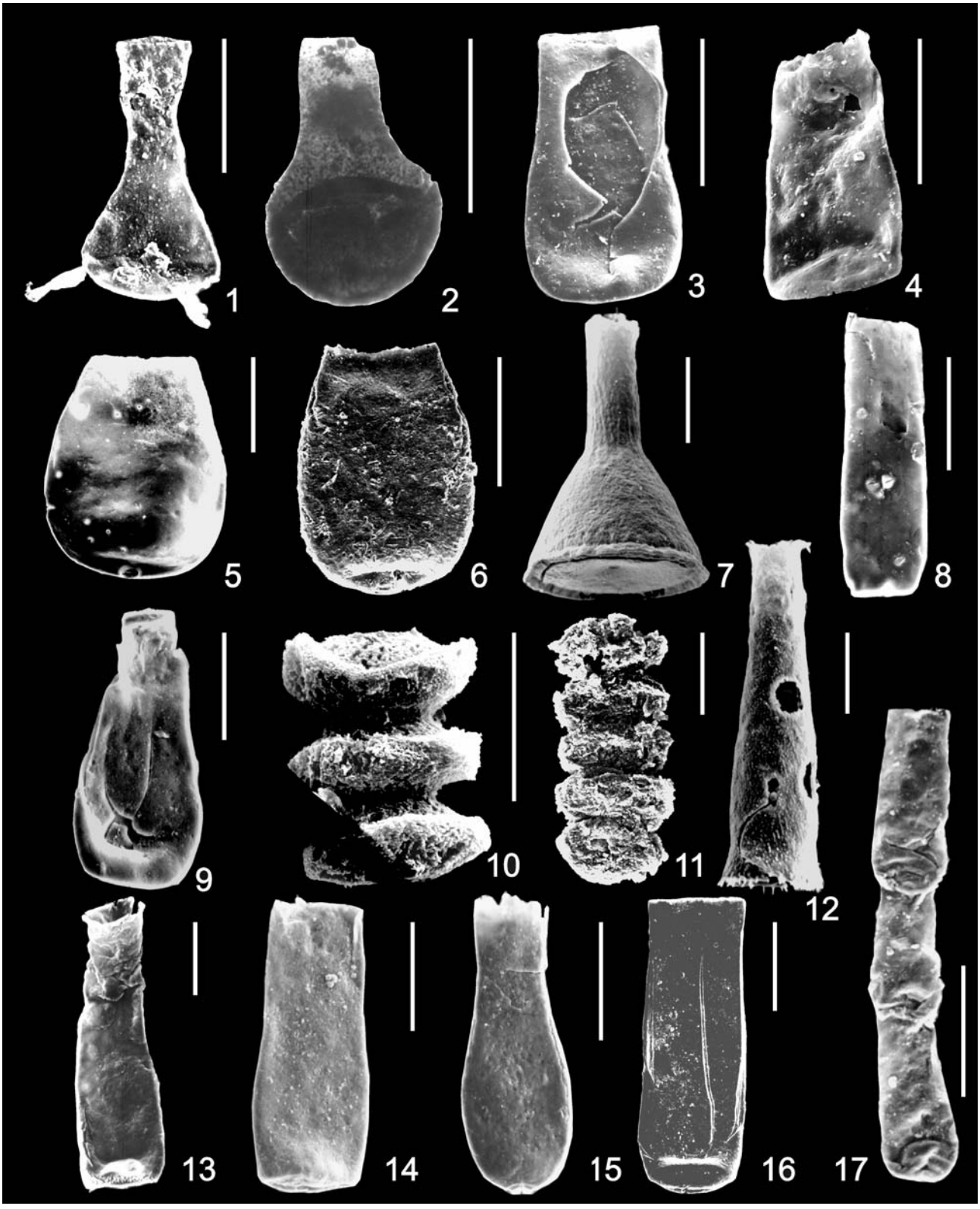
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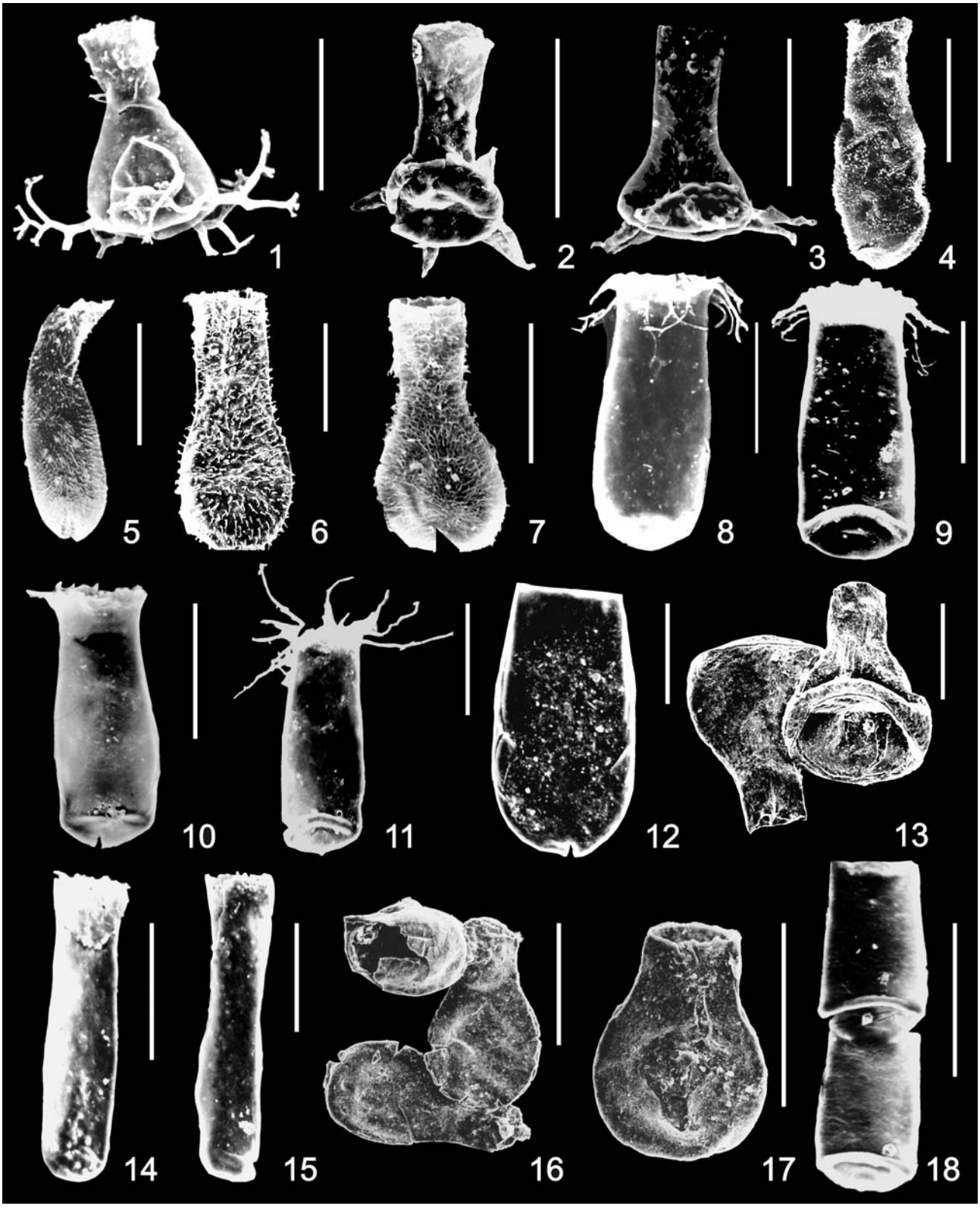
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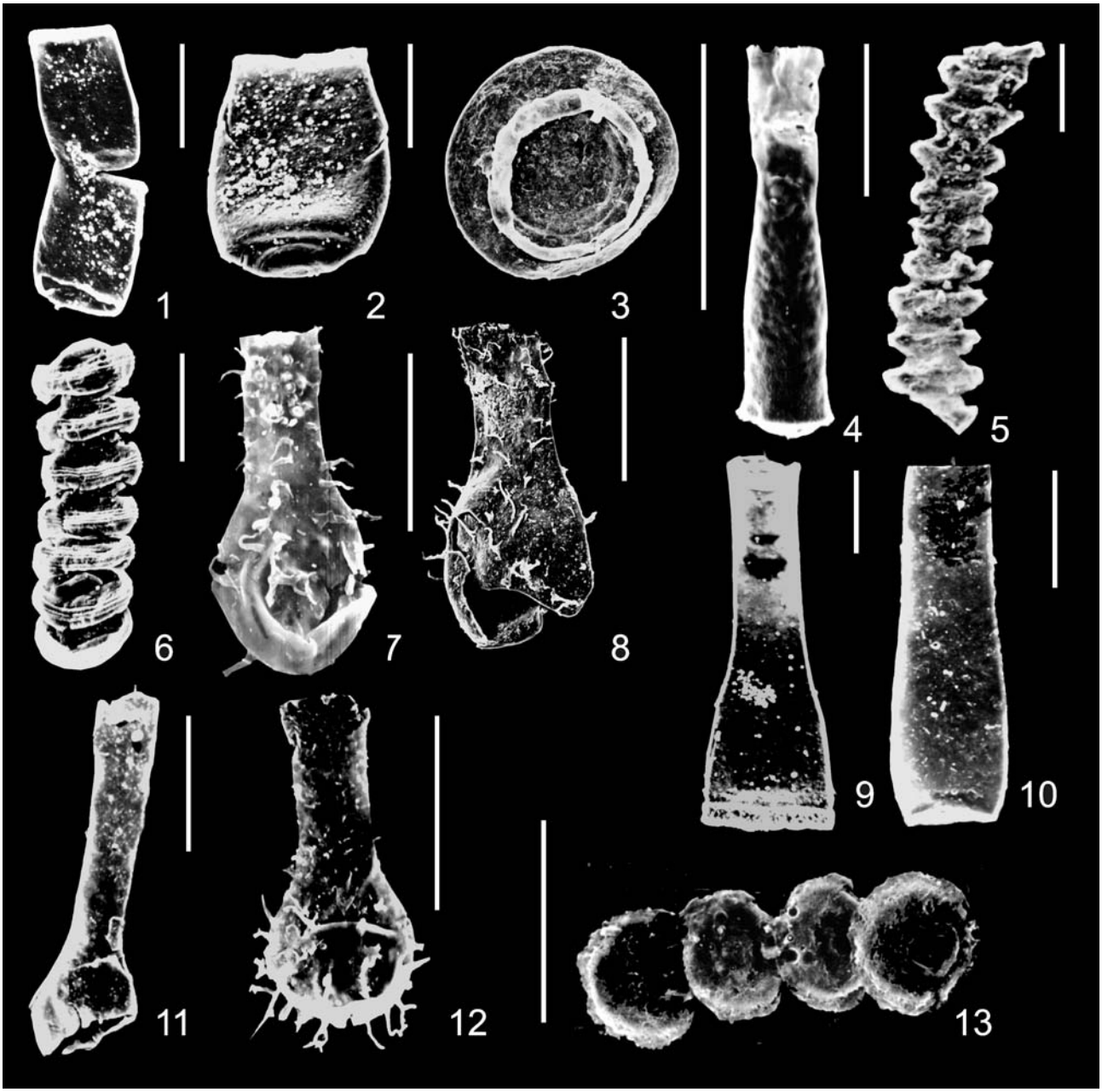

Plate VII. Chitinozoans from the Trombetas Group. Scale bars represent 100 μm.
1 – *Linochitina penequadrata* n. sp., two specimens in lateral view, well SR 07 (47.51–47.52 m). 2 – *Bursachitina wilhelmi* (Costa 1970), well SR 07 (47.51–47.52 m). 3 – *Margachitina*? sp., IGR, outcrop Igarapé da Rainha 4-65-73. 4 – *Pogonochitina* n. sp. A, well SR 01 (100.78–100.80 m). 5 – *Pterochitina* sp. B, well SR 01 (104.57–104.59 m). 6 – *Pterochitina* sp. B, well SR 07 (47.51–47.52 m). 7 – *Ramochitina* sp. sensu Grahn and Paris 1992, well SR 07 (28.30–28.31 m). 8 – *Ramochitina* sp. sensu Grahn and Paris 1992, IGR, outcrop Igarapé da Rainha 4-65-73. 9 – *Sagenachitina* sp. A, well SR 07 (47.51–47.52 m). 10 – *Tanuchitina* sp. A, well SR 07 (35.86–35.87 m). 11 – *Angochitina*? *thadeui* Paris 1981, well SR 10 (57.17–57.19 m). 12 – *Ramochitina illiziensis* Boumendjel 1985, well SR 07 (25.09–25.10 m). 13 – *Pterochitina deichaii* Taugourdeau 1963, chain with four specimens, well SR 03 (71.46–71.48 m).