

# Chitinozoans from the Ordovician Los Azules Formation, Central Precordillera, Argentina

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**ABSTRACT:** Chitinozoans from the Los Azules Formation, central Precordillera of Argentina are documented. The formation is divided into three members. Two chitinozoan assemblages are recognized: the late Llanvirn Lower Los Azules Palynological Assemblage in the middle member includes smooth forms, while the early Caradoc Upper Los Azules Palynological Assemblage, from the upper member, is mainly composed of ornamented specimens. Two new species are described: *Eisenackitina yolei* Ottone and Holfeltz and *Hercoclitina volkheimeri* Ottone and Holfeltz. The Los Azules chitinozoan faunas have species in common with contemporaneous assemblages from Laurentia but also northern Gondwana and Baltica.

## INTRODUCTION

The Ordovician System is represented by extensive carbonate and siliciclastic rocks in the Eastern and Central Precordillera and a thick weakly metamorphosed siliciclastic succession, including mafic-ultramafic rocks, in Western Precordillera. The proposed allochthonous nature of the Precordillera has been discussed in numerous papers (e.g. Pakhurst and Rapela 1998).

This paper systematically documents the chitinozoans recovered from the Middle Ordovician Los Azules Formation in the Argentine Precordillera. This geological province is located in western Argentina, between 29° and 33° S lat. and 68°15' and 69°45' W long.

Very little is known about Ordovician chitinozoans from Argentina (Volkheimer et al. 1980a, b; Ottone et al. 1992, 1995). Previous paleontological contributions concerning the Los Azules Formation have so far dealt with graptolite faunas (e.g. Cuerdo and Furque 1975; Ortega 1987, 1995; Mitchell et al. 1998), but, conodonts, plant microfossils and organic-walled microphytoplankton are also known from this unit (Hünicken and Ortega 1987; Ortega et al. 1996; Ottone et al. 1999).

The aim of this contribution is to complement a previous paper by the authors (Ottone et al. 1999) and to add to the micropaleontological knowledge of the Los Azules Formation providing documentation on chitinozoan faunas.

## GEOLOGICAL AND PALEONTOLOGICAL SETTING

Ordovician black shales are widespread in the Argentine Precordillera (Furque and Cuerdo 1979; Baldi et al. 1982, 1989). The black shales of the Gualcamayo and Los Azules formations were deposited in different parts of the Eastern and Central Precordillera (Baldi and Beresi 1981; Astini 1994a, b; Carrera and Astini 1998), paraconformably overlying a thick Cambrian/Early Ordovician calcareous sequence. These units

display abundant graptolite and conodont faunas with subordinate brachiopods, trilobites, nautiloids and phyllocarid remains. Organic-walled microfossils are also present (Volkheimer et al. 1980a; Ottone and Holfeltz 1992; Ottone et al. 1999).

The Los Azules Formation (Harrington in: Harrington and Leanza 1957) occurs as a narrow linear, approximately meridional outcrop, in the western flank of the Cerro Viejo de Huaco. The outcrop is between Jáchal and Huaco, northern San Juan Province (30°11' to 30°15'S, 68°34' to 68°35'W) in the Central Precordillera (text-fig. 1). The total thickness of this unit reaches ca. 318m. The Los Azules Formation is divided into three members (Ortega 1987). The lower member is ca. 10m thick and is predominantly composed of massive, dark argillites with subordinate K-bentonite levels dated at ca. 461±7/-10 Ma (Huff et al. 1995, 1998). The middle member is ca. 220m thick and essentially comprises laminated siltstones. The upper member, ca. 188m thick, includes calcareous silty shales interbedded with mudstones and coquinas.

The lower member of the Los Azules Formation contains graptolites assignable to the early Llanvirn *Undulograptus austrodentatus* Zone (*Undulograptus sinicus* Subzone) (Mitchell et al. 1998, Ortega and Albanesi 1999). The lower strata of the middle member include graptolites of the *Pterograptus elegans* Zone associated with conodonts of the *Eoplacognathus suecicus* Zone. The upper strata of the middle member are characterized by biserial graptolites of the *Hustedograptus tereiusculus* Zone and conodonts of the *Pygodus serra* Zone of late Llanvirn age. The presence in the upper member of graptolites of the early Caradoc *Climacograptus bicornis* Zone, and conodonts of the *Baltoniodus variabilis* or *Baltoniodus gerdæ* Subzones (*Amorphognathus tvaerensis* Zone), indicates the existence of a stratigraphic gap between the middle and upper members of the Los Azules Formation (Ortega 1987, 1995; Ortega et al. 1996; Ottone et al. 1999).

## MATERIAL AND METHODS

The chitinozoans were principally recovered from shales at Los Azules Creek, ca. 7 km south of La Ciénaga (text-fig. 1). G. L. Albanesi and G. Ortega are responsible for sampling and most geological information provided here. E. G. Ottone and G. D. Holfeltz prepared the palynological section of the paper.

Twenty-five productive samples were examined. Eighteen samples come from the middle member of the unit (samples LA 10, 15, 17, 18, 20, 22, 25, 32, 42, 46, 55, 60, 65, 68, 78, 89, 92 and 120) and the rest from the upper member (samples LA 237, 239, 240, 243, 244, 245 and 246). For the stratigraphical distribution of samples see Ottone et al. (1999).

Laboratory procedures for extraction and concentration of chitinozoans followed standard techniques (Miller 1996). Chitinozoans were photographed in light microscopy using a Leitz Wetzlar Orthomat camera attached to a Leitz Orthoplan microscope. Chitinozoans picked for SEM (Scanning Electron Microscopy) were transferred to a circular coverslip. The coverslip was posteriorly mounted on a SEM stub and coated with gold. Specimens were viewed and photographed using a Leitz AMR 1200 SEM.

The slides, prefixed BAFC-PI, and the SEM coverslips are housed in the palynological collection of the Geological Sciences Department, Buenos Aires University, Argentina.

## CHITINOZOAN CONTENT AND BIOSTRATIGRAPHIC IMPLICATIONS

The middle and upper members of the Los Azules Formation yielded abundant, relatively well-preserved palynomorphs. The lower member is barren of palynomorphs.

The distribution of chitinozoan, organic-walled phytoplankton and spore species throughout the Los Azules Formation denotes the existence of two distinct palynological assemblages (Ottone et al. 1999): the lower Los Azules Palynological Assemblage (LAL), and the upper Los Azules Palynological Assemblage (LAU) (text fig. 2).

The LAL Assemblage occurs in the middle member of the formation. The most abundant forms are the leiosphaerids, making up about 83-98% of the total. Essentially smooth-walled chitinozoans are subordinate (generally less than 10% of the total palynological content). Chitinozoan species of the LAL Assemblage are: *Calpichitina megastrophica* Achab 1984, *Calpichitina* sp. A, *Cyathochitina dispar* Benoit and Taugourdeau 1961, *Cyathochitina* sp. cf. *C. campanulaeformis* (Eisenack 1931), *Cyathochitina* sp. cf. *C. jenkinsi* Neville 1974, *Conochitina dolosa* Laufeld 1967, *Conochitina minnesotensis* (Stauffer 1933), *Desmochitina minor* forma *amphorea* Eisenack 1931, *Desmochitina minor* forma *ovulum* Eisenack 1962, *Desmochitina minor* forma *typica* Eisenack 1931, *Hyalochitina* sp. A, *Lagenochitina cylindrica* Eisenack 1931 and *Lagenochitina* sp. cf. *L. baltica* Eisenack 1931 (Table 1).

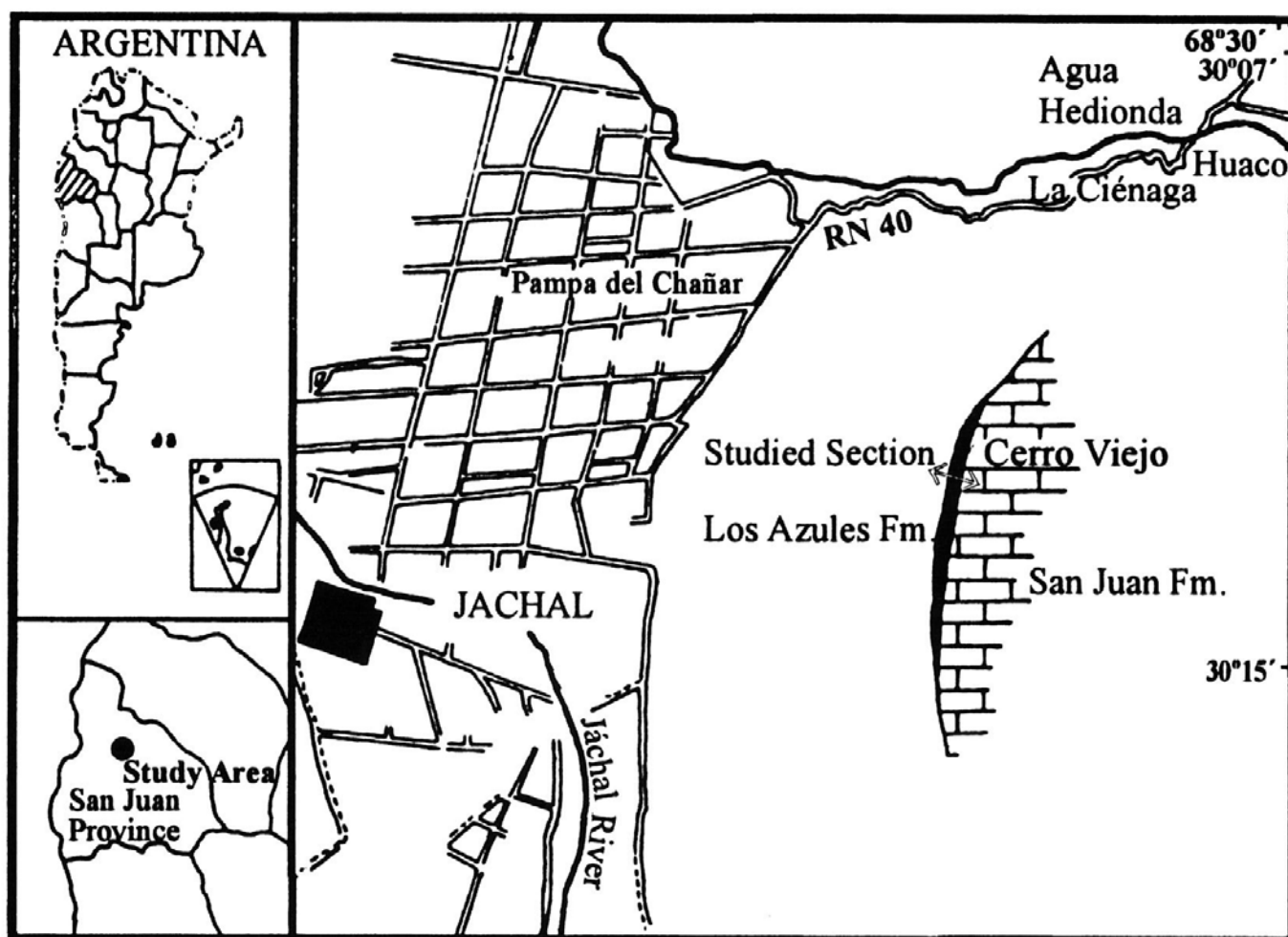
The LAU Assemblage is present in the upper member of the formation. Profusely ornamented chitinozoans dominate the assemblage, accounting for 60-81% of the total. Acritarchs, leiosphaerids, and scolecodonts are minor constituents. Chitinozoans reported from the LAU Assemblage are: *Angochitina* sp. A, *Armoricochitina* sp. cf. *A. nigerica* (Bouché 1965), *Belonechitina punctata* Paris 1981, *Belonechitina* sp. A, *Calpichitina* sp. A, *Conochitina dolosa* Laufeld 1967, *Cono-*

*chitina minnesotensis* (Stauffer 1933), *Conochitina? pygmaea* Achab 1987, *Cyathochitina* sp. cf. *C. campanulaeformis* (Eisenack 1931), *Cyathochitina* sp. cf. *C. jenkinsi* Neville 1974, *Eisenackitina yolei* Ottone and Holfeltz n. sp., *Hercochitina volkheimerii* Ottone and Holfeltz n. sp., *Kalochitina multispinata* Jansonius 1964, and *Kalochitina* sp. cf. *K. multispinata* Jansonius 1964 (Table 1).

Regarding the biostratigraphic value of individual species, forms of the late Llanvirn LAL Palynological Assemblage such as the cosmopolitan species *Desmochitina minor* (different forms) span the Llanvirn/Caradoc. Another cosmopolitan species, *Conochitina minnesotensis*, is also present in the LAL (Elaouad Debbaj 1986; Miller 1996; Siesser et al. 1998). *Conochitina dolosa*, *C. minnesotensis* and *D. minor* (different forms) were recorded from late Llanvirn/early Caradoc levels of Baltica by Laufeld (1967). Forms similar to *Cyathochitina* sp. cf. *C. campanulaeformis* were quoted from the Arenig-Llanvirn of northwestern Brazil (Grahn 1991) and from the early Caradoc of northeastern Canada (Achab 1984, 1986). *Calpichitina megastrophica*, *Cyathochitina* sp. cf. *C. jenkinsi* and probably *Lagenochitina* sp. cf. *L. baltica* (cf. *Lagenochitina* sp. A of Achab 1986) are common in the late Llanvirn/early Caradoc *Conochitina hirsuta/Lagenochitina* sp. A Zone from Quebec and western Newfoundland (Achab 1989). Forms also present in this zone are *Desmochitina minor* forma *minor* (Martin 1975; Achab 1984) and probably *Desmochitina minor* forma *ovulum* (Achab 1984, pl. I, 11, 14).

The early Caradoc LAU Palynological Assemblage includes characteristic species of Northern Gondwana, Laurentia and Baltica. The species *Armoricochitina nigerica* (cf. A. sp. cf. A. *nigerica* as reported herein) is known from the Ashgill of Northern Gondwana whilst *Conochitina dolosa* is a typical species of the Caradoc/Ashgill of Northern Gondwana and Laurentia (Elaouad Debbaj 1986; Achab 1991; Paris 1990, 1996; Achab and Asselin 1995). Other forms such as *Conochitina? pygmaea*, known from the Ashgill, *Kalochitina multispinata*, present in Caradoc/Ashgill levels, and the species *Cyathochitina* sp. cf. *C. jenkinsi* and probably *Lagenochitina* sp. cf. *L. baltica* (cf. *Lagenochitina* sp. A of Achab 1986), quoted from the Llanvirn/Caradoc, are exclusive of Laurentia up to now (Martin 1975, 1983; Jenkins and Legault 1979; Achab 1986, 1987, 1989; Miller 1996). Forms similar to *Kalochitina multispinata* were also cited as *Belonechitina hirsuta* (Laufeld 1967) in Caradoc levels of Baltica (Laufeld 1967; Nölvac and Grahn 1993; Achab and Asselin 1995). The genus *Hercochitina* Jansonius 1964 is common in the Caradoc/Ashgill of Laurentia (Jenkins and Legault 1979; Melchin and Legault 1985; Achab 1987), but is also represented in the late Llanvirn of northern Gondwana (Paris 1981, 1990; Gutiérrez-Marco et al. 1996). *Conochitina dolosa* and *C. minnesotensis* are also present in the LAU Assemblage.

Graptolite, conodont and chitinozoan data suggest that the Lower Los Azules Palynological Assemblage is of late Llanvirn age (Ottone et al. 1999) and can be correlated to the *Conochitina hirsuta/Lagenochitina* sp. A Zone from Quebec and western Newfoundland (Achab 1989). Graptolite and conodont data suggest an early Caradoc age for the Upper Palynological Assemblage (Ottone et al. 1999). However, the presence of *Conochitina? pygmaea* which defines the *Conochitina? pygmaea/Hercochitina cristata* biozone of the basal Ashgill in Quebec (Achab 1989), together with specimens comparable to *Armoricochitina nigerica* points out a younger age,



TEXT-FIGURE 1  
Location of studied area.

probably late Caradoc/early Ashgill. The first appearance datum (FAD) of different species of graptolites and conodonts were adopted by the Subcommission on Ordovician Stratigraphy in the demarcation of Ordovician series. The appearance of *C. pygmaea* and *A. sp. cf. A. nigerica* in the Upper Palynological Assemblage, in younger levels than in Laurentia and Northern Gondwana, probably reflects that these forms originated in Precordillera and later reached their acme in Laurentia and Northern Gondwana.

#### PALEOBIOGEOGRAPHIC REMARKS

The Precordillera is currently considered as part of an allochthonous, Laurentian-derivative terrane accreted to Gondwana (southwestern South American margin) during the early Paleozoic (Pankhurst and Rapela 1998; Benedetto et al. 1999; Aceñolaza and Toselli in press).

The pattern of the biogeographic distribution of conodont and graptolite faunas demonstrates a distinctive provincialism in the Middle Ordovician, as it was observed in the Argentine Precordillera (e.g. Maletz and Ortega 1995; Albanesi et al. 1995; Albanesi 1998; Ottone et al. 1999). Currently regarded as useful biogeographic tools, chitinozoan distribution reflects a

certain provincialism during the Ordovician (Paris and Robardet 1990; Achab 1991; Achab et al. 1992; Miller 1996).

The LAL Assemblage, including different Cyathochitinae, Desmochitinae and Lagenochitinae, has species in common with northern Gondwana, Baltica and mainly with Laurentia. The LAU Assemblage also includes species characteristic of Laurentia, such as *Conochitina? pygmaea*, *Cyathochitina sp. cf. C. jenkinsi* and *Kalochitina multispinata*, and others which are also present in northern Gondwana, such as *Armoricochitina sp. cf. A. nigerica* and *Conochitina dolosa*, and Baltica, such as *Conochitina dolosa* and *C. minnesotensis*.

According to some authors (e.g. Benedetto et al. 1999), geological and paleontological data indicate that since the Lower Ordovician the Precordillera microplate migrated from Laurentia colliding with Gondwana near the Ordovician/Silurian boundary. Following this interpretation, text-figure 3 indicates the approximate placement of the Precordillera terrane through the Llanvirn/Caradoc interval and the pattern of paleoceanographic currents (modified from Christiansen and Stouge 1999). This reconstruction could explain the presence of mixed planktic chitinozoan faunas, strongly dominated by Laurentian species, in the Llanvirn/Caradoc of the Precordillera.

British Series	Formation	Member	PALYNOLOGICAL ASSEMBLAGES	GRAPTOLITE ZONES	CONODONT ZONES
Caradoc	Los Azules	Upper	<i>Upper Los Azules Palynological Assemblage</i>	<i>Climacograptus bicornis</i>	<i>Amorphognathus tvaerensis</i>
Llanvirn		Middle	<i>Lower Los Azules Palynological Assemblage</i>	<i>Hustedograptus teretiusculus</i>	<i>Pygodus serra</i>
				<i>Pterograptus elegans</i>	
		Lower		<i>Undulograptus austrodenitatus</i>	

TEXT-FIGURE 2

Biostratigraphic zonations of the Los Azules Formation in the Cerro Viejo de Huaco area (after Ottone et al. 1999).

## SPECIES LIST

Suprageneric classification of chitinozoans follows the scheme of Paris et al. (1999).

Order OPERCULATIFERA Eisenack 1931

Family DESMOCHITINIDAE Eisenack 1931 emend. Paris 1981

Subfamily DESMOCHITININAE Paris 1981

Genus *Desmochitina* Eisenack 1931

Type Species *Desmochitina nodosa* Eisenack 1931

*Desmochitina minor* forma *amphorea* Eisenack 1931

*Desmochitina minor* forma *ovulum* Eisenack 1962

*Desmochitina minor* forma *typica* Eisenack 1931

Genus *Calpichitina* Wilson and Hedlund 1964

Type Species *Calpichitina scabiosa* Wilson and Hedlund 1964

*Calpichitina megastrophica* Achab 1984

*Calpichitina* sp. A

Subfamily EISENACKITININAE Paris 1981

Genus *Eisenackitina* Jansonius 1964 restrict. Paris 1981

Type Species *Eisenackitina castor* Jansonius 1964

*Eisenackitina yolei* Ottone and Holfeltz n. sp.

Genus *Kalochitina* Jansonius 1964

Type Species *Kalochitina multispinata* Jansonius 1964

*Kalochitina multispinata* Jansonius 1964

*Kalochitina* sp. cf. *K. multispinata* Jansonius 1964

Subfamily PTEROCHITININAE Paris 1981

Genus *Armoricochitina* Paris 1981

Type Species *Linochitina? ceneratiensis* Paris 1976

*Armoricochitina* sp. cf. *A. nigerica* (Bouché 1965)

Order PROSOMATIFERA Eisenack 1972

Family CONOCHITINIDAE Eisenack 1931 emend. Paris 1981

Subfamily BELONECHITININAE Paris 1981

Genus *Belonechitina* Jansonius 1964

Type Species *Conochitina micracantha robusta* Eisenack 1959

*Belonechitina punctata* Paris 1981

*Belonechitina* sp. A

Genus *Hercochitina* Jansonius 1964

Type Species *Hercochitina crickmayi* Jansonius 1964

*Hercochitina volkheimerii* Ottone and Holfeltz n. sp.

Subfamily CONOCHITININAE Paris 1981

Genus *Conochitina* Eisenack 1931 emend. Paris, Grahn,

Nestor and Lakova 1999

Type Species *Conochitina claviformis* Eisenack 1931

*Conochitina dolosa* Laufeld 1967

*Conochitina minnesotensis* (Stauffer 1933)

*Conochitina? pygmaea* Achab 1987

Subfamily TANUCHITININAE Paris 1981

Genus *Hyalochitina* Paris and Grahn in Paris et al. (1999)

Type Species *Cyathochitina hyalophrys* Eisenack 1959

*Hyalochitina* sp. A

Family LAGENOCHITINIDAE Eisenack 1931 emend. Paris 1981

Subfamily ANGOCHITININAE Paris 1981

Genus *Angochitina* Eisenack 1931

Type Species *Angochitina echinata* Eisenack 1931

*Angochitina* sp. A

Subfamily CYATHOCHITININAE Paris 1981

Genus *Cyathochitina* Eisenack 1955 emend. Paris, Grahn,

Nestor and Lakova 1999

Type Species *Conochitina campanulaeformis* Eisenack 1931

*Cyathochitina dispar* Benoit and Taugourdeau 1961

*Cyathochitina* sp. cf. *C. campanulaeformis* (Eisenack 1931)

*Cyathochitina* sp. cf. *C. jenkinsi* Neville 1974

Subfamily LAGENOCHITININAE Paris 1981

Genus *Lagenochitina* Eisenack 1931 emend. Paris, Grahn,

Nestor and Lakova 1999

Type Species *Lagenochitina baltica* Eisenack 1931

*Lagenochitina cylindrica* Eisenack 1931

*Lagenochitina* sp. cf. *L. baltica* Eisenack 1931

## SYSTEMATIC DESCRIPTIONS AND REMARKS

New species are proposed when specimens are relatively abundant and well-preserved. Only new taxa are described systematically, except for *Conochitina? pygmaea* Achab 1987, *Kalochitina* sp. cf. *K. multispinata* Jansonius 1964, *Armoricochitina* sp. cf. *A. nigerica* (Bouché 1965), *Cyathochitina* sp. cf. *C. campanulaeformis* (Eisenack 1931), *Cyathochitina* sp. cf. *C. jenkinsi* Neville 1974 and *Lagenochitina* sp. cf. *L. baltica* which required descriptions or additional remarks.

Genus *Calpichitina* Wilson and Hedlund 1964

Type species: *Calpichitina scabiosa* Wilson and Hedlund 1964

*Calpichitina* sp. A

Plate 1, figures 10 and 12

**Description:** Specimens are subcircular in polar view, scarcely broader than high. Aperture is surrounded by a short collar with a straight to slightly crenulate edge. Chamber diameter/aperture diameter ratio: 2.4. Vesicle wall is smooth to chagrinate.

**Dimensions (3 specimens):** Chamber diameter: 78(86)94µm, aperture diameter: 30(36)42µm.

**Comparisons:** *Calpichitina* sp. A. differs from the *Calpichitina complanata* (Eisenack 1932)/*Calpichitina lenticularis* (Bouché 1965) group in possessing a larger aperture, and from *Calpichitina megastrophica* Achab 1984 by its short collarete. The specimens figured by Neville (1974, pl. IV, 1-21) as



*Calpichitina* cf. *lata* (Schallreuter 1963) show a less development of the collar. The specimens figured by Grahn (1981a, pl. 14, figs. A-B) as *Desmochitina complanata* Eisenack 1932, from the Llanvirn/Caradoc of Öland are comparable with *Calpichitina* sp. A. The specimens figured as *Desmochitina* cf. *D. lata* Schallreuter 1963 by Achab (1983, pl. 2, figs. 1-4) display a granulate wall.

Genus *Eisenackitina* Jansonius 1964 restrict. Paris 1981

Type Species: *Eisenackitina castor* Jansonius 1964

*Eisenackitina yolei* Ottone and Holfeltz n. sp.

Plate 1, figures 1, 2, 5 and 6

Holotype: Sample LA 237, Slide 994(1), England Finder: C27/4; plate 1, figure 2.

Type locality: Los Azules Creek, Jáchal Department, San Juan Province, Argentina.

Type stratum: Los Azules Formation.

Description: Vesicle subcylindrical, devoid of neck, having its greatest width near the aboral pole. Total length/maximum diameter ratio is about one. Aboral end rounded. Vesicle wall covered with moderately abundant, solid, simple and multirooted spines. Chains not observed.

Dimensions (15 specimens): Total length: 73(95)131µm, maximum diameter: 77(89)116µm; aperture diameter: 55(60)67µm; simple spines: 1-1.5µm in basal diameter, up to 4-5µm high, multirooted spines: 8-10µm in basal diameter.

Derivation of Name: *Yole*, Huarpe Indian name for vessel of knitting vegetal fibers.

Comparisons: The specimen figured by Soufiane and Achab (1993, pl. 2, fig. 5) as *Kalochitina inflata* (Taugourdeau 1961) is slightly pyriform in outline and lacks multirooted spines. *Eisenackitina subditiva* Winchester-Seeto 1996 bears interlocking, simple and bifurcate spines, occasionally with elongate bases.

Genus *Kalochitina* Jansonius 1964

Type Species: *Kalochitina multispinata* Jansonius 1964

*Kalochitina* sp. cf. *K. multispinata* Jansonius 1964

Plate 1, figure 4

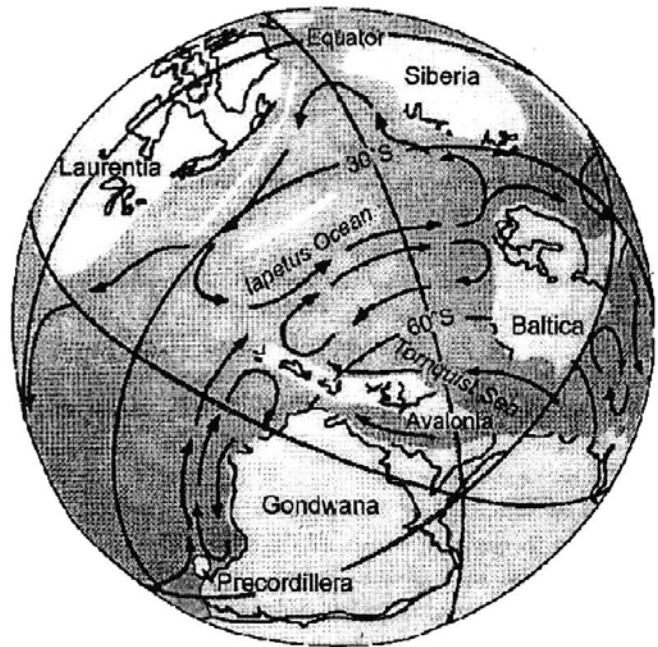
Remarks: Specimens of Los Azules referred as *Kalochitina* sp. cf. *K. multispinata* Jansonius 1964 are shorter and possess fewer and shorter spines than the type material (see also for comparison pl. 1, fig. 8). The forms figured by Jansonius (1964) as *Kalochitina* cf. *inflata* (Taugourdeau 1961) display a longer neck. *Kalochitina inflata* (Taugourdeau 1961) has a different outline and larger spines conforming discontinuous ridges (Asselin, personal communication, February 2000). The specimen figured as *Kalochitina inflata* (Taugourdeau 1961) by Soufiane and Achab (1993, pl. 2, fig. 5) from the Tadla Basin of Morocco, shows a similar outline to than the Argentinian species.

Genus *Armoricochitina* Paris 1981

Type Species: *Linochitina? ceneratiensis* Paris 1976

*Armoricochitina* sp. cf. *A. nigerica* (Bouché 1965)

Plate 2, figure 10



TEXT-FIGURE 3

Paleogeographic reconstruction of the Precordillera terrane at the Llanvirn/Caradoc (modified from Christiansen and Stouge 1999).

Remarks: The precise assignment of the Argentinian forms is hindered by the fact that only few specimens were encountered, all having a damaged neck.

Genus *Belonechitina* Jansonius 1964

Type Species: *Conochitina micracantha robusta* Eisenack 1959

*Belonechitina* sp. A

Plate 1, figures 14 and 15

Description: Vesicle elongated, subcylindrical to cylindroconical. Base flat. Vesicle maximum diameter slightly above the basal margin. Flexure and shoulders absent. Mucron not observed. Vesicle ornamented by irregular granules and tubercles, 2-4 µm in basal diameter, and short spines.

Dimensions (4 specimens): Total length 116(118)119µm, maximum diameter 98(104)109µm; neck diameter 49(55)60µm.

Comparisons: *Belonechitina kjelstromi* (Martin 1975) has a mainly spinose ornamentation with spines arranged in transversal rows (Martin, 1975, 1983; Achab, 1987). The ornamentation of the Argentinian specimens appears to be more variable.

Genus *Hercochitina* Jansonius 1964

Type Species: *Hercochitina crickmayi* Jansonius 1964

*Hercochitina volkheimerii* Ottone and Holfeltz n. sp.

Plate 2, figures 1, 2, 5-7

Holotype: Sample LA 243, Slide 1002(3), England Finder: Q50/4; plate 2, figure 6.

*Type locality:* Los Azules Creek, Jáchal Department, San Juan Province, Argentina.

*Type stratum:* Los Azules Formation.

*Description:* Vesicle slightly cylindroconical to subcylindrical. Base convex. Basal edge rounded. Flanks straight to weakly convex, tapering to a cylindrical neck. Shoulders absent, flexure indistinct. Vesicle maximum diameter above the basal end. Neck diameter/vesicle maximum diameter ratio is about 0.8. Vesicle ornamentation of aligned rows of complex spines interconnected at their bases forming incomplete longitudinal ridges. Ridges are present on the chamber and neck, but indistinct towards the aboral margin. Spines up to 6 µm in height, joined at their tips by longitudinal, discontinuous bars. Prosome is located at the base of neck.

*Dimensions (18 specimens):* Total length: 124(168)205 µm, maximum diameter: 63(77)93 µm; neck diameter: 49(59)71 µm.

*Derivation of name:* In honour of Wolfgang Volkheimer, for his contribution to Argentinian chitinozoan knowledge.

*Comparisons:* *Hercichitina repsinata* (Schallreuter 1981) is longer and displays a minute ornamentation. *Hercichitina lindsayensis* Melchin and Legault 1985 has a markedly cylindroconical outline (maximum diameter/neck diameter ratio, ca. 1.3 in *H. volkheimerii*, ca. 1.7 in *H. lindsayensis*). *Belonechitina robusta* (Eisenack 1959) has a conical outline and a spinose ornamentation not forming longitudinal ridges in general.

Genus *Conochitina* Eisenack 1931 emend. Paris, Grahn, Nestor and Lakova 1999

*Type Species:* *Conochitina claviformis* Eisenack 1931

*Conochitina? pygmaea* Achab 1987

Plate 3, figure 4

*Remarks:* The holotype of the species *Conochitina? pygmaea*, as well as the Los Azules specimens display a bottle form. Further, following Achab (1987, p. 1218), we regard the generic assignment of the species *pygmaea* as doubtful.

*Comparisons:* *Lagenochitina?* sp. figured by Achab and Asselin (1995) from the Canadian Arctic Platform is similar to the Argentinian specimens. The specimens figured as *Lagenochitina* sp. A aff. *capax* by Grahn et al. (1996, pl. 3, figs. 1-2) are superficially comparable to the Los Azules forms. *Lagenochitina brevicollis* Taugourdeau and de Jekhowsky 1960 has an ovoidal chamber.

Genus *Hyalochitina* Paris and Grahn in Paris et al. (1999)

*Type Species:* *Cyathochitina hyalophrys* Eisenack 1959

*Hyalochitina* sp. A

Plate 1, figure 16

*Description:* Vesicle apparently conocylindrical. Base flat. Basal edge with a short carina. Flanks convex. Vesicle maximum diameter towards the middle of the chamber. Vesicle wall smooth.

*Dimensions (1 specimen):* Vesicle diameter 104 µm; neck diameter 54 µm.

*Comparison:* *Hyalochitina hyalophrys* (Eisenack 1959) is larger and more slender (Eisenack 1959; Achab 1987). *Cyatho-*

*chitina dispar* Benoit and Taugourdeau 1961 has a conspicuous flexure and more developed convex flanks.

Genus *Angochitina* Eisenack 1931 emend. Paris, Grahn, Nestor and Lakova 1999

*Type Species:* *Angochitina echinata* Eisenack 1931

*Angochitina* sp. A

Plate 2, figure 12

*Description:* Vesicle bottle-shaped with the greatest width above the rounded aboral end. Base convex. Flexure distinct, shoulders inconspicuous. Neck cylindrical, comprising about one-third of the vesicle length. Neck diameter about half the maximum diameter. Vesicle ornamentation of sparse spines, up to 8 µm high.

*Dimensions (3 specimens):* Total length: 105(133)162 µm, maximum diameter: 85(93)100 µm; neck length: 50(52)54 µm, neck diameter: 51(56)60 µm.

*Comparison:* The specimens figured as *Sphaerochitina gracqui* Martin 1983 by Martin (1983, pl. 1, fig. 9, pl. 4, fig. 18) are somewhat comparable to *Angochitina* sp. A, however, these forms appear to possess shorter spines and granules. The specimen figured as *Angochitina capillata* Eisenack 1937 by Jenkins (1969, pl. 1, fig. 12) is comparable to *Angochitina* sp. A. The holotype of *Angochitina? oklahomensis* Taugourdeau 1965, and the specimens figured by Martin (1983, pl. 5, fig. 29) as *Conochitina oklahomensis* (Taugourdeau 1965) are similar to *Angochitina* sp. A.

Genus *Cyathochitina* Eisenack 1955 emend. Paris, Grahn, Nestor and Lakova 1999

*Type Species:* *Conochitina campanulaeformis* Eisenack 1931

*Cyathochitina* sp. cf. *C. campanulaeformis* (Eisenack 1931)

Plate 3, figures 1-3 and 5

*Description:* Chamber conical. Base flat or slightly convex. Basal edge with a short carina, 6-7 µm wide. Flanks convex, tapering to a cylindrical neck. Flexure and shoulders distinct. Chamber maximum diameter towards the aboral margin. Neck length about 0.4 of the total length. Neck diameter about half the maximum width. Prosome occasionally present. Vesicle wall smooth.

*Dimensions (17 specimens):* Total length: 232(252)278 µm, maximum diameter: 122(153)186 µm; chamber length: 133(158)209 µm; neck length: 82(95)116 µm, neck width: 69(76)83 µm.

*Remarks:* The Argentinian forms are stouter and display a wider cylindrical neck than those figured by Eisenack (1931, 1962) as type and neotype of the species *campanulaeformis* (neck diameter about half the maximum width).

*Comparison:* *Cyathochitina campanulaeformis* (Eisenack 1931) cited by Grahn (1991, fig. 8,7), and *Cyathochitina* cf. *campanulaeformis* (Eisenack 1931) cited by Achab (1984, pl. IV, figs. 3, 4, 6, 7) and Achab (1986, pl. III, figs. 12-16) are similar to the Argentinian specimens. *Cyathochitina* cf. *macastyensis* Achab 1978 cited by Achab (1987, pl. 9, figs. 17, 18) has a shorter neck. Close comparison between *Cyathochitina campanulaeformis* (Eisenack 1931) figured by Grahn (1981b, fig. 5G) with the Argentinian forms is hindered by the fact that the neck of the former is apparently damaged. *Cyathochitina kuckersiana patagiata* Jenkins 1969 displays more distinct

TABLE 1  
Stratigraphic distribution of chitinozoans and sampling levels.

FORMATION		LOS AZULES																								
MEMBER		MIDDLE												UPPER												
SPECIES	SAMPLE	LA 10	LA 15	LA 17	LA 18	LA 20	LA 22	LA 25	LA 32	LA 42	LA 46	LA 55	LA 60	LA 65	LA 68	LA 78	LA 89	LA 92	LA 120	LA 237	LA 239	LA 240	LA 243	LA 244	LA 245	LA 246
<i>Desmochitina minor</i> forma <i>amphorea</i>																										
<i>Desmochitina minor</i> forma <i>ovulum</i>																										
<i>Desmochitina minor</i> forma <i>typica</i>																										
<i>Calpichitina megastrophica</i>																										
<i>Calpichitina</i> sp. A																										
<i>Eisenckitina yolei</i>																										
<i>Kalochitina multispinata</i>																										
<i>Kalochitina</i> sp. cf. <i>K. multispinata</i>																										
<i>Armoricochitina</i> sp. cf. <i>A. nigerica</i>																										
<i>Belonechitina punctata</i>																										
<i>Belonechitina</i> sp. A																										
<i>Hercochitina volkheimeri</i>																										
<i>Conochitina dolosa</i>																										
<i>Conochitina minnesotensis</i>																										
<i>Conochitina</i> ? <i>pygmaea</i>																										
<i>Hyalochitina</i> sp. A																										
<i>Angochitina</i> sp. A																										
<i>Cyathochitina dispar</i>																										
<i>Cyathochitina</i> sp. cf. <i>C. campanulaeformis</i>																										
<i>Cyathochitina</i> sp. cf. <i>C. jenkinsi</i>																										
<i>Lagenochitina cylindrica</i>																										
<i>Lagenochitina</i> sp. cf. <i>L. baltica</i>																										

shoulders. *Cyathochitina kuckersiana* Eisenack 1962 figured by Achab (1987, pl. 9, figs. 13-16) has a more developed carina and a wider chamber. *Cyathochitina hunderumensis* Grahn et al. 1996 displays a wider carina (see Grahn 1980 for measurements). The specimen figured as *Cyathochitina campanulaeformis* (Eisenack 1931) by Paris (1981, pl. 13, fig. 15) seem to possess a more developed carina. *Cyathochitina caputoi* da Costa 1971 from the Early Silurian of Brazil possesses a wider basal diameter.

*Cyathochitina* sp. cf. *C. jenkinsi* Neville 1984  
Plate 3, figures 6, 8 and 9

**Description:** Chamber conico-claviform, weakly constricted at the basal edge. Base flat. Basal edge supporting a short carina, ca. 6µm wide. Flanks convex tapering to a cylindrical neck. Flexure and shoulders distinct. Vesicle maximum diameter in the lower half of the chamber. Neck length/total length ratio about 0.4. Neck diameter/maximum chamber diameter ratio about 0.6. Vesicle wall smooth.

**Dimensions (15 specimens):** Total length: 271(302)370µm, maximum diameter: 124(141)151µm; chamber length: 174(196)226µm; neck length: 79(107)144µm, neck width: 64(78)90µm.

**Remarks:** Most chitinozoans figured by Achab (1984) as *Cyathochitina* cf. *C. jenkinsi* Neville 1974, from subsurface Anticosti Island, appear to be entirely comparable with the specimens described above, except those figured in pl. V, figs. 6 and 9, that are stouter. *Cyathochitina jenkinsi* Neville 1974, from western Newfoundland are also similar to the Argentinian

forms, with the exception of one specimen (Neville, 1974, pl. III, 28) that displays longitudinal ribs often restricted to the aboral end. Close comparison between *Cyathochitina jenkinsi* Neville 1974 and *Cyathochitina* cf. *jenkinsi* Neville 1974 (in Achab 1984) is difficult because we do not know whether the longitudinal ribbing mentioned by Neville (1974, p. 197) is a constant character. In addition, the posterior treatment of these forms by Achab is equivocal because she considers them as synonyms (Achab 1989, p. 21) or as different entities (Achab 1986, p. 285-286, pl. V, 6-9; 1989, p. 18, fig. 3).

**Comparison:** *Cyathochitina dispar* Benoit and Taugourdeau 1961 possess a convex chamber bottom. *Laufeldochitina protolardeuxi* Soufiane and Achab 1993 from the Tadla Basin of Morocco is slender and has an indistinct flexure.

Genus *Lagenochitina* Eisenack 1931 emend. Paris, Grahn, Nestor and Lakova 1999

**Type Species:** *Lagenochitina baltica* Eisenack 1931

*Lagenochitina* sp. cf. *L. baltica* Eisenack 1931  
Plate 2, figure 4

**Remarks:** The specimens referred to in this paper as *Lagenochitina* sp. cf. *L. baltica* Eisenack 1931, are more slender than those originally described by Eisenack (1931) (total length/maximum diameter ratio, ca. 3 in the Los Azules specimens, ca. 2 in Eisenack's 1931 specimens).

**Comparison:** The specimens referred to as *Lagenochitina* sp. A by Achab (1986, pl. V, 6 and 8, no 7 and 9?), are comparable with the Argentinian forms.

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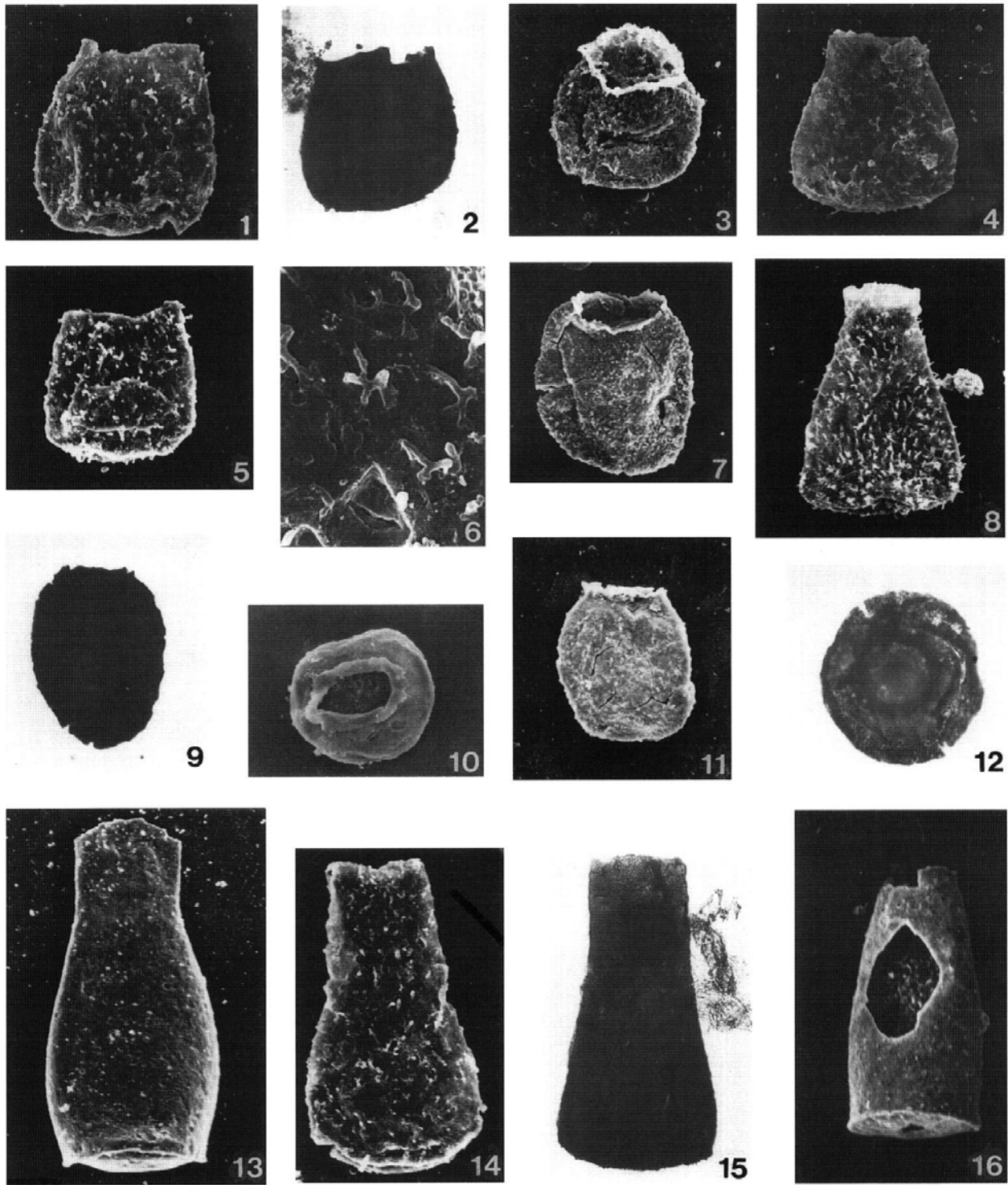
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## PLATE 1

Photomicrographs were taken using Scanning Electron Microscopy (SEM) or transmitted light (TL). Specimens in TL are denoted by the slide number followed by the England Finder reference. Magnifications are  $\times 300$  unless stated otherwise.

- 1 *Eisenackitina yolei* Ottone and Holfeltz n. sp. Sample LA 237, BAFC-PI 994, SEM.
- 2 *Eisenackitina yolei* Ottone and Holfeltz n. sp. Sample LA 237, BAFC-PI 994(1): C27/4. Holotype.
- 3 *Calpichitina megastrophica* Achab 1984. Sample LA 18, BAFC-PI 1010, SEM.
- 4 *Kalochitina* sp. cf. *K. multispinata* Jansonius 1964. Sample LA 237, BAFC-PI 994, SEM.
- 5 *Eisenackitina yolei* Ottone and Holfeltz n. sp. Sample LA 243, BAFC-PI 1002, SEM.
- 6 *Eisenackitina yolei* Ottone and Holfeltz n. sp. Sample LA 243, BAFC-PI 1002, SEM,  $\times 900$ .
- 7 *Desmochitina minor* forma *typica* Eisenack 1931. Sample LA 15, BAFC-PI 1000, SEM.
- 8 *Kalochitina multispinata* Jansonius 1964. Sample LA 237, BAFC-PI 994, SEM.
- 9 *Desmochitina minor* forma *ovulum* Eisenack 1962. Sample LA 89, BAFC-PI 992(7): O45/0.
- 10 *Calpichitina* sp. A. Sample LA 25, BAFC-PI 996, SEM.
- 11 *Desmochitina minor* forma *typica* Eisenack 1931. Sample LA 15, BAFC-PI 1000, SEM.
- 12 *Calpichitina* sp. A, Sample LA 60, BAFC-PI 934(7): O37/1.
- 13 *Cyathochitina dispar* Benoit and Taugourdeau 1961. Sample LA 15, BAFC-PI 1000, SEM.
- 14 *Belonechitina* sp. A. Sample LA 243, BAFC-PI 1002, SEM.
- 15 *Belonechitina* sp. A. Sample LA 237, BAFC-PI 994(2): M20/2.
- 16 *Hyalochitina* sp. A. Sample LA 15, BAFC-PI 1000, SEM,  $\times 200$ .



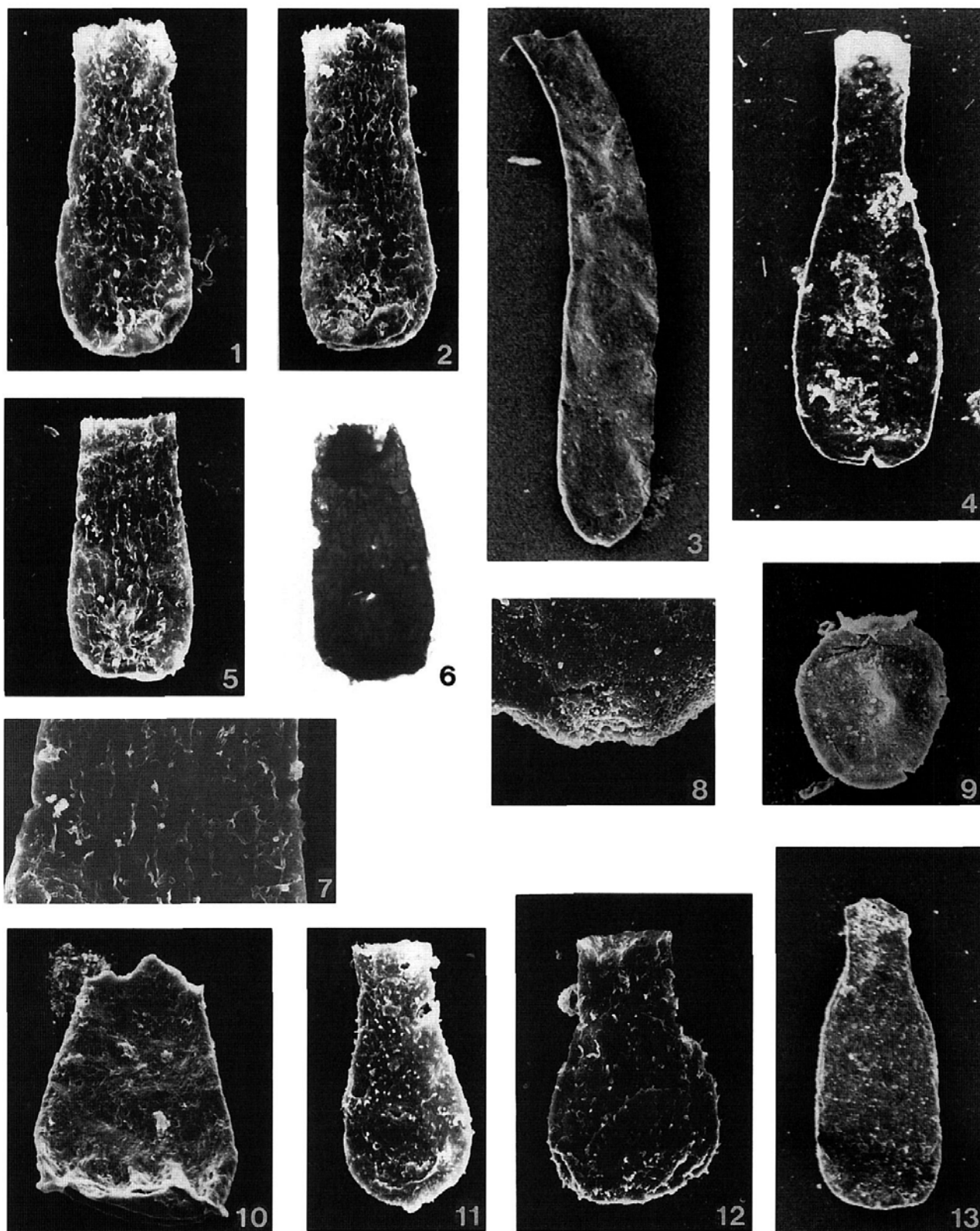


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## PLATE 2

Photomicrographs were taken using Scanning Electron Microscopy (SEM) or transmitted light (TL). Specimens in TL are denoted by the slide number followed by the England Finder reference. Magnifications are  $\times 300$  unless stated otherwise.

- 1 *Hercochitina volkheimerii* Ottone and Holfeltz n. sp. Sample LA 243, BAFC-PI 1002, SEM.
- 2 *Hercochitina volkheimerii* Ottone and Holfeltz n. sp. Sample LA 243, BAFC-PI 1002, SEM.
- 3 *Conochitina minnesotensis* (Staufer 1931). Sample LA 15, BAFC-PI 1000, SEM,  $\times 100$ .
- 4 *Lagenochitina* sp. cf. *L. baltica* Eisenack 1931. Sample LA 18, BAFC-PI 1010, SEM,  $\times 150$ .
- 5 *Hercochitina volkheimerii* Ottone and Holfeltz n. sp. Sample LA 243, BAFC-PI 1002, SEM.
- 6 *Hercochitina volkheimerii* Ottone and Holfeltz n. sp. Sample LA 243, BAFC-PI 1002(3): Q50/4. Holotype.
- 7 *Hercochitina volkheimerii* Ottone and Holfeltz n. sp. Sample LA 243, BAFC-PI 1002, SEM, detail of specimen figured in 5,  $\times 750$ .
- 8 *Conochitina minnesotensis* (Staufer 1933). Sample LA 15, BAFC-PI 1000, SEM,  $\times 1000$ .
- 9 *Desmochitina minor* forma *amphorea* Eisenack 1931. Sample LA 55, BAFC-PI 1005, SEM.
- 10 *Armoricochitina* sp. cf. *A. nigerica* (Bouché 1965). Sample LA 243, BAFC-PI 1002, SEM.
- 11 *Belonechitina punctata* Paris 1981. Sample LA 243, BAFC-PI 1002, SEM.
- 12 *Angochitina* sp. A. Sample LA 243, BAFC-PI 1002, SEM.
- 13 *Lagenochitina cylindrica* Eisenack 1931. Sample LA 55, BAFC-PI 1005, SEM,  $\times 100$ .



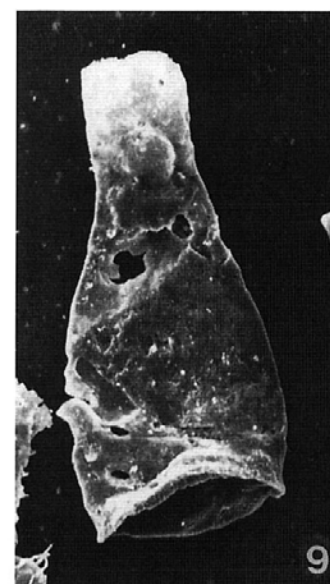
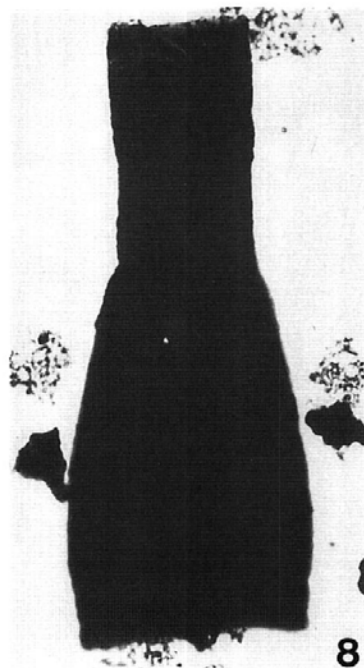
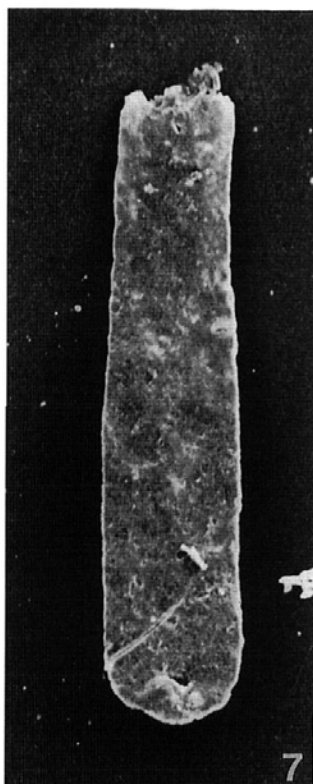
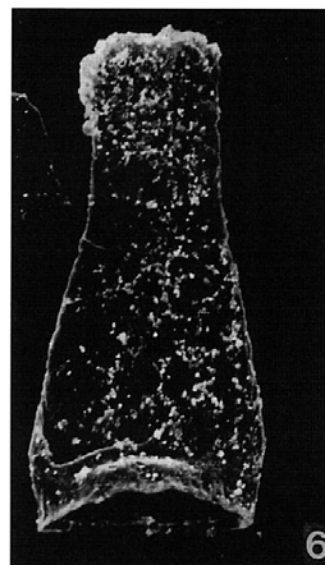
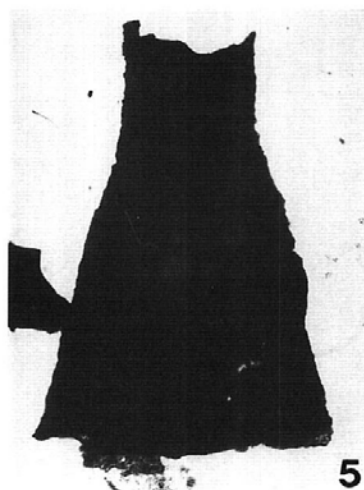
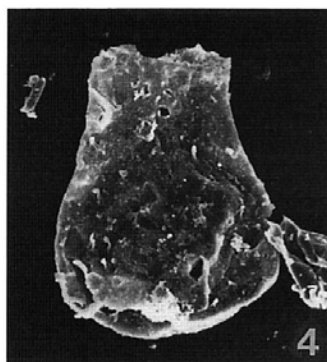
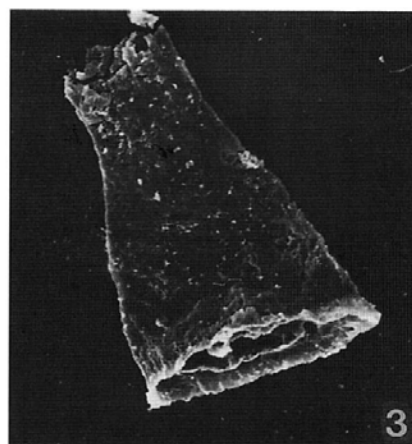
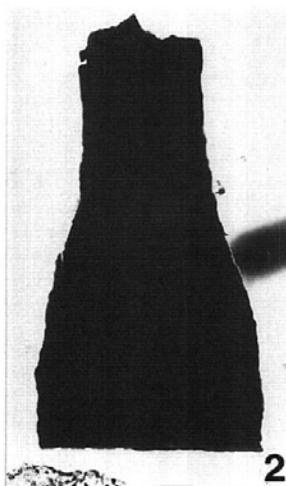
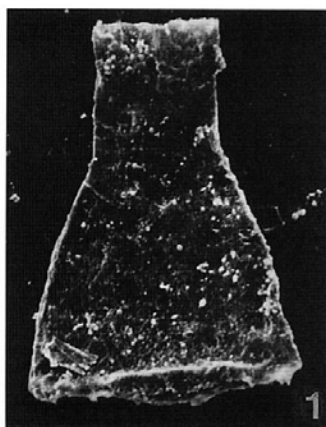
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### PLATE 3

Photomicrographs were taken using Scanning Electron Microscopy (SEM) or transmitted light (TL). Specimens in TL are denoted by the slide number followed by the England Finder reference. Magnifications are  $\times 200$  unless stated otherwise.

- 1 *Cyathochitina* sp. cf. *C. campanulaeformis* (Eisenack 1931). Sample LA 25, BAFC-PI 996, SEM.
- 2 *Cyathochitina* sp. cf. *C. campanulaeformis* (Eisenack 1931). Sample LA 25, BAFC-PI 996(2): N34/0.
- 3 *Cyathochitina* sp. cf. *C. campanulaeformis* (Eisenack 1931). Sample LA 25, BAFC-PI 996, SEM.
- 4 *Conochitina*? *pygmaea* Achab 1987. Sample LA 243, BAFC-PI 1002, SEM,  $\times 300$ .
- 5 *Cyathochitina* sp. cf. *C. campanulaeformis* (Eisenack 1931). Sample LA 60, BAFC-PI 934(2): D22/0.
- 6 *Cyathochitina* sp. cf. *C. jenkinsi* Neville 1974. Sample LA 22, BAFC-PI 1001, SEM.
- 7 *Conochitina dolosa* Laufeld 1967. Sample LA 15, BAFC-PI 1000, SEM,  $\times 300$ .
- 8 *Cyathochitina* sp. cf. *C. jenkinsi* Neville 1974. Sample LA 25, BAFC-PI 996(1): T31/4.
- 9 *Cyathochitina* sp. cf. *C. jenkinsi* Neville 1974. Sample LA 237, BAFC-PI 994, SEM.





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