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Silurian microplankton from the Cachipunco Formation (Santa Bárbara Range; Andina Central Basin), Jujuy, Argentina

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Abstract: The palynological content of Cachipunco Formation is described in this contribution. This formation lies in the Santa Barbara Range, Jujuy Province, and outcrops at two localities: Angosto Los Pereyras and Cumbre los Pereyras. The more complete succession is the one from Angosto Los Pereyras, where the formation comprises 273 m of dark siltstones interstratified with thin sandstones and without visible base or top. The microfloristic associations are characterized by the presence of: *Ammonidium ludloviense* (Lister) Dorning, *Barbestiastra barbata* (Downie) Sarjeant & Stancliffe, *Domasia quadrispinosa* Hill, *Leiofusa exilata* Dorning, *L. parvitatis* Loeblich, *Multiplicisphaeridium arbusculum* Dorning, *M. eoplancktonicum* (Eisenack) Lister, *Neoveryhachium carminae* Cramer, *Proteolobus cylindricus* Al-Ruwaili, *Tylotopalla maraca* Díez & Cramer, *T. robustispinosa* (Downie) Eisenack *et al*., *Veryhachium trisphaeridium* Downie, and *Ambitisporites avitus* Hoffmeister. According to the stratigraphic distribution of the theses species, the age of the Cachipunco Formation can be constrained to a Wenlockian-Ludlovian range. A new species is proposed *Multiplicisphaeridium baldisii* sp. nov.

Key words: Acritarchs, biostratigraphy, Middle-Upper Silurian, Cachipunco Formation, Santa Barbara Range, Jujuy, Argentina.

Resumen. **Microplancton Silúrico de la Formación Cachipunco (sierra de Santa Bárbara; Cuenca Andina Central), Jujuy, Argentina**. En este trabajo se describe el contenido palinológico de la Formación Cachipunco, proveniente de dos localidades (Angosto Los Pereyras y Cumbre Los Pereyras) de la Sierra Santa Bárbara, Provincia de Jujuy. En Angosto los Pereyras, donde la Formación Cachipunco presenta la sección sedimentaria más desarrollada (273 m de potencia), incluye pelitas negras interestartificadas con arenisacs finas; sin base ni teschos visibles. Las asociaciones microflorísticas están caracterizadas por la presencia de: *Ammonidium ludloviense* (Lister) Dorning, *Barbestiastra barbata* (Downie) Sarjeant & Stancliffe, *Domasia quadrispinosa* Hill, *Leiofusa exilata* Dorning, *L. parvitatis* Loeblich, *Multiplicisphaeridium arbusculum* Dorning, *M. eoplancktonicum* (Eisenack) Lister, *Neoveryhachium carminae* Cramer, *Proteolobus cylindricus* Al-Ruwaili, *Tylotopalla maraca* Díez & Cramer, *T. robustispinosa* (Downie) Eisenack *et al*., *Veryhachium trisphaeridium* Downie y *Ambitisporites avitus* Hoffmeister. A partir del registro estratigráfico de estas especies la sección fosilífera de la Formación Cachipunco Formation puede ser referido al intervalo Wenlockiano-Ludloviano. Una nueva especie es propuesta: *Multiplicisphaeridium baldisii* sp. nov.

Palabras clave: Acritarcas, biostratigrafía, Silúrico Medio-Superior, Fomación Cachipunco, Sierra Santa Bárbara, Jujuy, Argentina.

INTRODUCTION

During the Silurian, in the Central Andean Basin (Fig. 1.1), that extends from Peru to North-western Argentina (Benedetto *et al.*, 1992), a thick and fossiliferous, siliciclastic succession was deposited, which appears nowadays deformed and dismembered due to the Andean tectonics. In North-western Argentina, the most important outcrops of this succession are those from the Subandean Range, especially the ones from the Zapla and Santa Barbara ranges, in Jujuy and Salta provinces.

In the Zapla range (Fig. 1.2), the main litostratigraphic units are Zapla Formation (Schlagintweit, 1943) and Lipeón Formation (Turner, 1960) while at Santa Barbara range, the correlative litostratigraphic units are

Cachipunco Formation (Padula *et al.,* 1967) and Arroyo Colorado (Andreis *et al.,* 1982).

Zapla Formation is composed mainly by argillaceous sandstones, which present disperse quartz clasts; sandstones and diamictits. It may reach up to 100 m in thickness and it was originally referred to the Llandoverian, based on stratigraphic correlation (Antelo, 1973; Cuerda & Antelo, 1973). Notwithstanding, more recent works (Monaldi & Boso, 1987; Astini *et al.,* 2004; Rubinstein, 2005; de La Puente & Rubinstein, 2007; Rubinstein *et al.*, 2007) reassigned it to the Ordovician due to the finding of *Dalmatina* at the top of the unit. Lipeón Formation comprises a monotonous succession, between 600 and 1,600 metres in thickness, of siltstones and fossiliferous sandstones. According to Andreis *et al.* (1982), it formed in an extern marine platform, beneath the wave base level. Benedetto *et al.* (1992) gave this formation a Llandoverian-Pridolian age, but Rubinstein & Toro (2006) assigned it to the Llandovery-Ludlow based on the palynomorphs and graptolites content.

The stratigraphy of Silurian-Devonian rocks in the Santa Bárbara range has been described in several publications (*e.g.*, Padula *et al.,* 1967; Mingramm & Russo, 1972; Antelo, 1978; Mingramm *et al.,* 1979; Moreno Espeleta *et al.,* 1981; Pezzi & Mozetic, 1990; Vistalli, 1990; Starck, 1995; Aceñolaza *et al.,* 2000; Astini *et al.,* 2004).

In outline, Cachipunco Formation comprises a succession of laminated black shales, rich in fossils and pyrite, interstratified with quarcitic sandstones. It is partially equivalent to Lipeon Formation, with a greater participation of sandstones. According to Mingramm *et al.* (1979) it would have been deposited in a sublitoral marine environment. This unit was proposed by Padula *et al.* (1967) grouping the "piso Z1" of Hagerman (1933) and Bellmann´s "Gotlandico" (1962).

The fossil content of these rocks, mainly invertebrates and palynomorphs, has been extensively studied (Baldis, 1972; Antelo, 1978; Bultynck & Martin, 1982; Sánchez, 1990; Rubinstein, 1997, 2003; Grahn & Gutiérrez, 2001; Rubinstein & Toro, 2006).

The aim of the present paper is to discuss the palynological content (acritarchs, prasinophyceaes and spores), from the Cachipunco Formation, in the Santa Bárbara range (South-eastern Jujuy Province; Fig. 1.2).

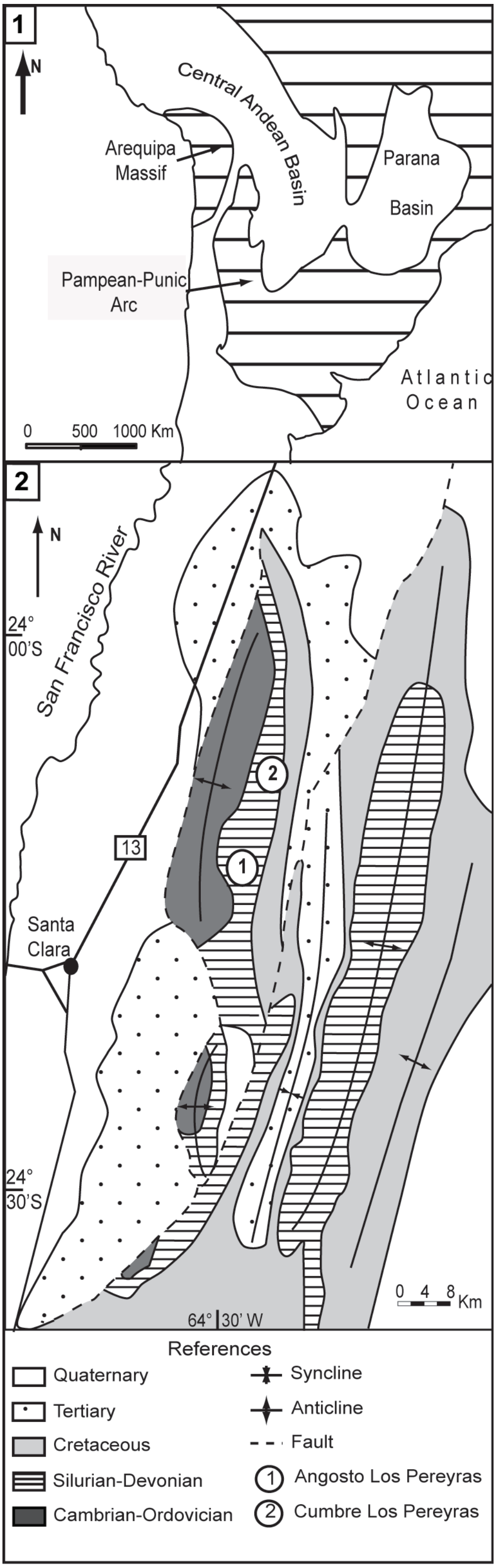


Fig. 1. **1,** Map showing the location of the Silurian Central Andean Basin in South America (Modified from Benedetto *et al.*, 1992). **2,** Geological Map of Santa Barbara Range.

GEOLOGICAL SETTING AND BIOSTRATIGRAPHY

The palynological samples were collected from two different sections both corresponding to the Cachipunco Formation: Angosto Los Pereyras and Cumbre Los Pereyras (Fig. 1.2). The area is located approximately 150 km to the Southeast of San Salvador de Jujuy, Jujuy Province.

Angosto Los Pereyras

Angosto Los Pereyras is located to the North of the Arroyo Colorado and to the East of Santa Clara City. At this location, Cachipunco Formation comprises 273 meters of micaceous, dark-grey to yellow siltstones without visible base or top (Fig. 2.1). These siltstones, which are bioturbated, are intercalated with thin beds of light-grey, micaceous, argillaceous fine sandstones

Cumbre Los Pereyras

This section is located near 8 kilometers to the north of Angosto Los Pereyras. It comprises 135 meters of siltstones and sandstones, of similar characteristics of those from Angosto Los Pereyras, but with a larger proportion of sandstones than in the latter (Fig. 2.2).

Biostratigraphy

Cachipunco Formation was originally referred to the Early Devonian due to the presence of macrofloristic remains (see Padula *et al.,* 1967, Mingramm *et al.,* 1979). Subsequently, was transferred to the Middle-Late Silurian (Baldis, 1972; Antelo, 1978; Vistalli, 1990), and more recently, Grahn & Gutiérrez (2001), assigned it a Late Llandoverian Early Pridolian age, based on the analysis of the chitinozoa content of the unit.

MATERIALS AND METHODS

Forty palynological samples were collected from the Cachipunco Formation, 30 of which were found to be productive. Samples were processed using palynological HCl-HF-HCl acid maceration techniques (see Wood *et al*., 1996). Slides were examined using light microscopy and scanning electronic microscopy.

Light photomicrographs were taken on an Olympus BX-51 microscope using an Olympus C-5000 digital camera, while the scanning micrographs were taken on Philips XL-30 at 20 kV. All figured material is housed in the collection of the MACN (Museo Argentino de Ciencias Naturales “B. Rivadavia”) under the prefixes BA Pal (Buenos Aires, Palynology). The specimen locations are referred using England Finder coordinates.

The preservation state of the material is quite bad, being the majority of specimens fragmented, often impregnated with pyrite and most of them showing signs of corrosion. Such situation made difficult the assignment of same palynomorphs.

For identification purposes, different measures were taken, as referred on the systematic section. Abbreviations of such measures are as follows: V∅ = Diameter of the vesicle; VW = Width of the vesicle; VL = Length of the vesicle; VT = Total length of the vesicle (including processes); PL = Length of the processes; PN = Number of processes; PØ = Diameter of the processes; P∅B = Diameter of the bases of the processes; P∅D = Diameter of the distal end of the processes; PL/V∅ = Length of the processes/vesicle diameter ratio; VW/VL = Vesicle width/vesicle length ratio; VW/VT = Vesicle width/vesicle total length ratio; ∅ = Diameter (for spores); Cw = Cingule width; Zw = Zone width. Such measures are presented in the format N1 (N2) N3, where N1 and N3 represent the minimum and the maximum value measured respectively, and N2 the mean for all the specimens evaluated. The number of specimens measured appears between brackets. In the Synonym and Distribution sections it is included primarily the material described for Argentina. For the graphic showing vertical and percentage distributions (Figs. 3 and 4) there where counted between 200 and 300 palynomorphs per slide.

SYSTEMATICS

Group ACRITARCHA Evitt 1963

Genus ***Ammonidium*** Lister 1970

Type species: *Ammonidium microcladum* (Downie) Lister 1970.

Ammonidium ludloviense (Lister) Dorning 1981

(Fig. 3.1)

1987 *Ammonidium rigidum* (aff.) var. *ludloviense* Lister; Pöthe de Baldis: 90, pl. I, fig. 1.

1993 *Ammonidium rigidum* var. *ludloviense* Lister; Rubinstein: 70.

1998 *Ammonidium waldronense* (Tappan & Loeblich) Dorning; Pöthe de Baldis: 6, pl. I, figs. 7-8.

Dimensions. V∅ = 20(25)30 μm, PL = 4(5)6 μm, P∅B = 2 μm, P∅D = 1 μm, PL/V∅ = 0.2, Eylima, 0.5 μm (2 specimens measured).

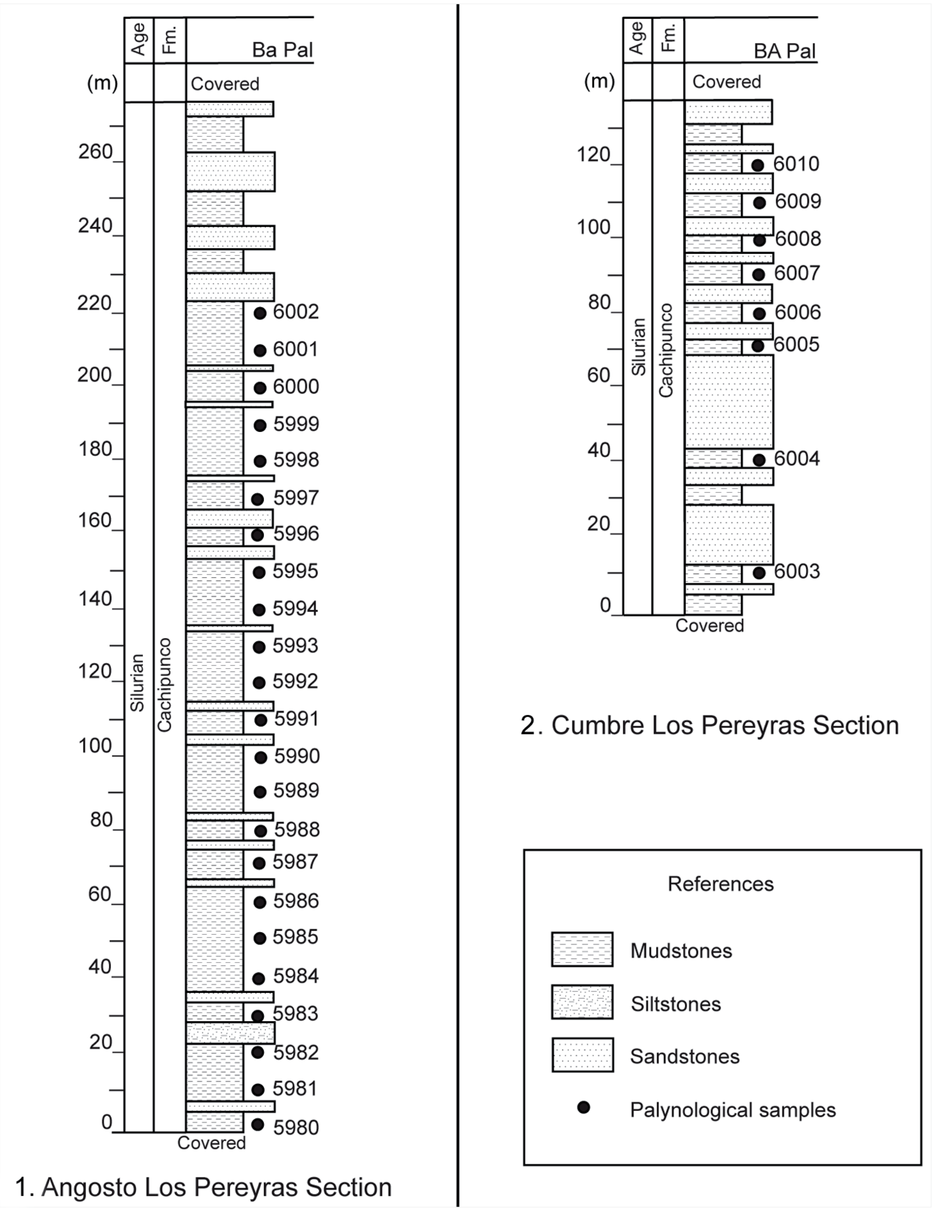


Fig. 2. Schematic stratigraphical logs of Angosto Los Pereyras and Cumbre Los Pereyras.

Remarks. *Ammonidium rigidum* (Deunff) var. *ludloviense* Lister as described and illustrated by Pöthe de Baldis (1987) it corresponds to the species described here due to the length and shape of its processes and the vesicle diameter. The specimen described by Pöthe de Baldis (1998) as *A. waldronense* (Tappan & Loeblich) Dorning is here reassigned to *A. ludloviense* owing to the length of its processes (3.5 μm). According to Tappan & Loeblich (1971) the length for *A. waldronensis* processes is between 5-10 μm.

Ammonidium* sp. cf. *A. waldronense
(Tappan & Loeblich) Dorning 1981
(Fig. 3.2)

1987 *Caiacorymbifer* cf. *waldronis* Tappan & Loeblich; Pöthe de Baldis: pl. 1, fig. 8.

Description. Vesicle spherical, hollow, single-walled. Eylima thin (0.5 mm). Numerous processes (near 30 visible), hollow and freely communicated with the vesicle interior. Processes tapered into distally equifurcate terminations. No excystment method observed.

Dimensions. V∅ = 22(24.5)27 μm, PL = 8(9)10 μm, P∅B = 1.5-2 μm, P∅D = 1 μm, PL/V∅ = 0.3(0.37)0.4 (5 specimens measured).

Remarks. These specimens are assigned to *Ammonidium* cf. *waldronense* (Tappan & Loeblich) Dorning since the number of processes is not as high as it is in the holotype (more than 40; Tappan & Loebliech, 1971) and no assessment of the vesicle ornamentation can be made due to the bad preservation state of the material. The material illustrated by Pöthe de Baldis (1987) as *Caiacorymbifer* cf. *waldronis* (*sic*) might be considered to be co-specific with the one described here, based on the processes characteristics and the relationship processes length/vesicle diameter (0.37 in Pöthe de Baldis 1987).

***Ammonidium* sp. A**

(Fig. 3.3)

Description. Vesicle spherical, hollow, with few (between 3-7), hollow, open-to-vesicle-interior, slightly tapering processes. Processes equifurcate distally into 3-5 spines. No excystment method observed.

Dimensions. VØ = 22(24)26 μm, PL = 12(16)20 μm, PØB = 2 μm (2 specimens measured).

Remarks. Owing to the ramification pattern that presents this specimen, we assigned it to the genus *Ammonidium*. A more accurate assignment could not be made due to the bad preservation of the material.

Genus ***Barathrisphaeridium*** Wicander 1974

Type species: *Barathrisphaeridium chagrinense* Wicander 1974.

***Barathrisphaeridium?* sp. A**

(Fig. 3.4)

Description. Vesicle spherical in outline, evenly covered with numerous (near 25) slender, flexible, relatively short, homomorphic, and acuminated processes. Processes are solid and do not communicate with vesicle interior. Excystment by rupture of the vesicle wall.

Dimensions. V∅ = 25(28.3)33 μm, PL = 7(9.6)13 μm, P∅B = 1(1.2)2 μm, P∅D = 0.5 μm (7 specimens measured).

Remarks. The bad state of preservation of the material does not allow the nature of the wall structure to be observed; therefore the species are doubtfully assigned to this genus. The specimens described by Rubinstein for Los Espejos Formation (Rubinstein, 1992b) as *Barathrisphaeridium?* sp. have significantly shorter processes.

Genus ***Barbestiastra*** Sarjeant & Stancliff 1994

Type species: *Barbestiastra barbata* (Downie) Sarjeant & Stancliffe 1994.

Barbestiastra barbata (Downie) Sarjeant & Stancliffe 1994

(Figs. 3.5, 7.5)

1971 *Estiastra* cf. *barbata* Downie; Pöthe de Baldis: 286, pl. 1, fig. 7.
1975a *Estiastra* aff. *barbata* Downie; Pöthe de Baldis: 494, pl. V, figs. 2, 5.

Dimensions. T = 77(87.25)94 μm, PL = 20(25)31 μm; 8 to 10 conical processes (4 specimens measured).

Remarks. The material described by Pöthe de Baldis (1971, 1975a) and doubtfully assigned to *Estiastra barbata* Downie is considered to be co specific with the specimens characterized here because both of them display similar features, in shape and ornamentation patterns.

Genus ***Cymbosphaeridium*** Lister 1970

Type species: *Cymbosphaeridium bikidum* Lister 1970.

***Cymbosphaeridium* sp. A**

(Fig. 3.7)

Description. Vesicle roughly spherical, dark-coloured, probably double-walled, with 10 transparent, hollow, columnar, flexible processes. Distal ends are open and present aculeate tips. No excystment method observed.

Dimensions. VØ = 47 μm, PØ = 4-6 μm, PL = 17 μm, PN = 7 (1 specimen measured).

Remarks. *Cymbosphaeridium pilar* (Cramer) Lister (1970) has a granulate vesicle and cauliflorate branching at the tips.

Genus ***Diexallophasis*** Loeblich emend. Sarjeant & Vavrdová 1997

Type species: *Diexallophasis remota* (Deunff) Playford 1977.

Diexallophasis denticulata (Stockmans & Willière) Loeblich 1970

(Fig. 3.118)

1997a *Diexallophasis* cf. *remota* (Deunff) Playford; Pöthe de Baldis: 41, pl. II, fig. 5.
?1997 *Evittia denticulata denticulata* (Cramer) Le Hérissé; Rubinstein: 164, pl. 7, fig. 11.
1997b *Diexallophasis remota* (Deunff) Playford; Pöthe de Baldis: 468, pl. I, fig. 15.

Dimensions. V∅ = 21(29.1)35 μm, PL = 18(25.7)32 μm, P∅B = 4(4.6)6μm, P∅D = 1(1.4)2 μm (26 specimens measured).
Remarks. Specimens observed here present different degrees of deformation due to folds in its wall. *Diexallophasis denticulata* and *D. remota* (Deunff) Playford (1977) have been considered by several authors (Playford, 1977; Sarjeant & Vavrdova, 1997) to be synonyms. Mullins (2002) maintained them as separated species, hinged on the characteristics of the processes, being broader-based and more robust in *D remota*, and the ornamentation of the vesicle, which is micropuntuate to foveolate in *D. denticulata*. Additionally to this, we consider *D. remota* to have a distinct sub polygonal vesicle, and more processes than *D. denticulata*. Therefore, we consider them to be different species.

The specimens described as *D.* cf. *remota* (Deunff) Playford by Pöthe de Baldis (1997a), clearly presents all the distinct characteristics of *D. denticulata*, a globular vesicle with few processes arising from it, so we reassign them herein. In the same way, the material illustrated by Pöthe de Baldis (1997b), depict similar characteristics to those of *D. denticulata*, a spherical vesicle, with 4-5 long processes, and therefore is reassigned to that species. Probably, the material described by Rubinstein (1997) as *Evittia denticulata denticulata* (Cramer) Le Hérissé, also corresponds to *D. denticulata*, since both preset similar vesicle and processes characteristics.

Diexallophasis remota (Deunff) Playford 1977

(Fig. 3.8)

Dimensions. V∅ = 22(28.2)36 μm, PL = 20(27.7)37 μm, P∅B = 3(3.9)5 μm, P∅D = 0.5-1.5 μm; 7-13 processes (20 specimens measured).
Remarks. *Diexallophasis denticulata* (Stockmans & Willière) Loeblich (1970) has lesser processes and a subspherical vesicle. *Diexallophasis downtongorgensis* Mullins (2004) has a smaller spherical vesicle with 4-7 processes.

***Diexallophasis* sp. A**

(Figs. 3.9, 7.1)

2000 *Exochoderma?* sp. aff. *E. arca* Wicander & Wood; Pöthe de Baldis: 332, pl. 3, fig. H.

Description. Vesicle quadrangular in outline, with straight sides. Eylima single-layered, laevigate to slightly granulate. One process developed at each corner, and one arising from the centre face of vesicle. Processes (4-6 in total) are hollow and communicate freely with the vesicle interior. They are ornamented with grana or small spines, and very lightly costate. Distally ended in a simple, closed, pointed tip. Some processes are truncated. Excystment method not observed.
Dimensions. V∅ = 24(28)31 μm, PL = 16(26)34 μm, PN = 5-7, P∅B = 5(5.3)7 μm, P∅D = 1(1.4)2 μm (16 specimens measured).
Remarks. The material described by Pöthe de Baldis (2000: *Exochoderma* sp. aff. *E. arca* Wicander & Wood) for Los Espejos Formation is considered to be co-specific with *Diexallophasis* sp. A since both have the same characteristics (similar vesicle length, equal number of processes and similar processes length). Both are differentiated from *Exochoderma arca* Wicander & Wood (1981), as the latter is larger and has most process bifurcated. *Diexallophasis* sp A is differentiate from *D. denticulata* due to the vesicle shape (being in the former much more polygonal than in the latter), to the presence of ridges in the base of the processes and the fact that distal ends in this species are acuminated and do not show any type of bifurcation. *Diexallophasis remota* is separated from *D.* sp A. based on this species has a quadrangular vesicle, with lesser processes (up to 6) than *D. remota.*

Diexallophasis mucronata (Stockmans & Willière) Priewalder has a smaller vesicle and its processes present a distinct pattern of branching (Stockmans & Willière, 1963; Priewalder, 1987). It differs from *D. downtongorgensis* Mullins (2004) in having a larger vesicle, more notorious ornamentation and the same wall thickness in both, vesicle and processes.

Genus ***Domasia*** Downie emend. Hill 1974

Type species: *Domasia trispinosa* Downie emend. Hill 1974.

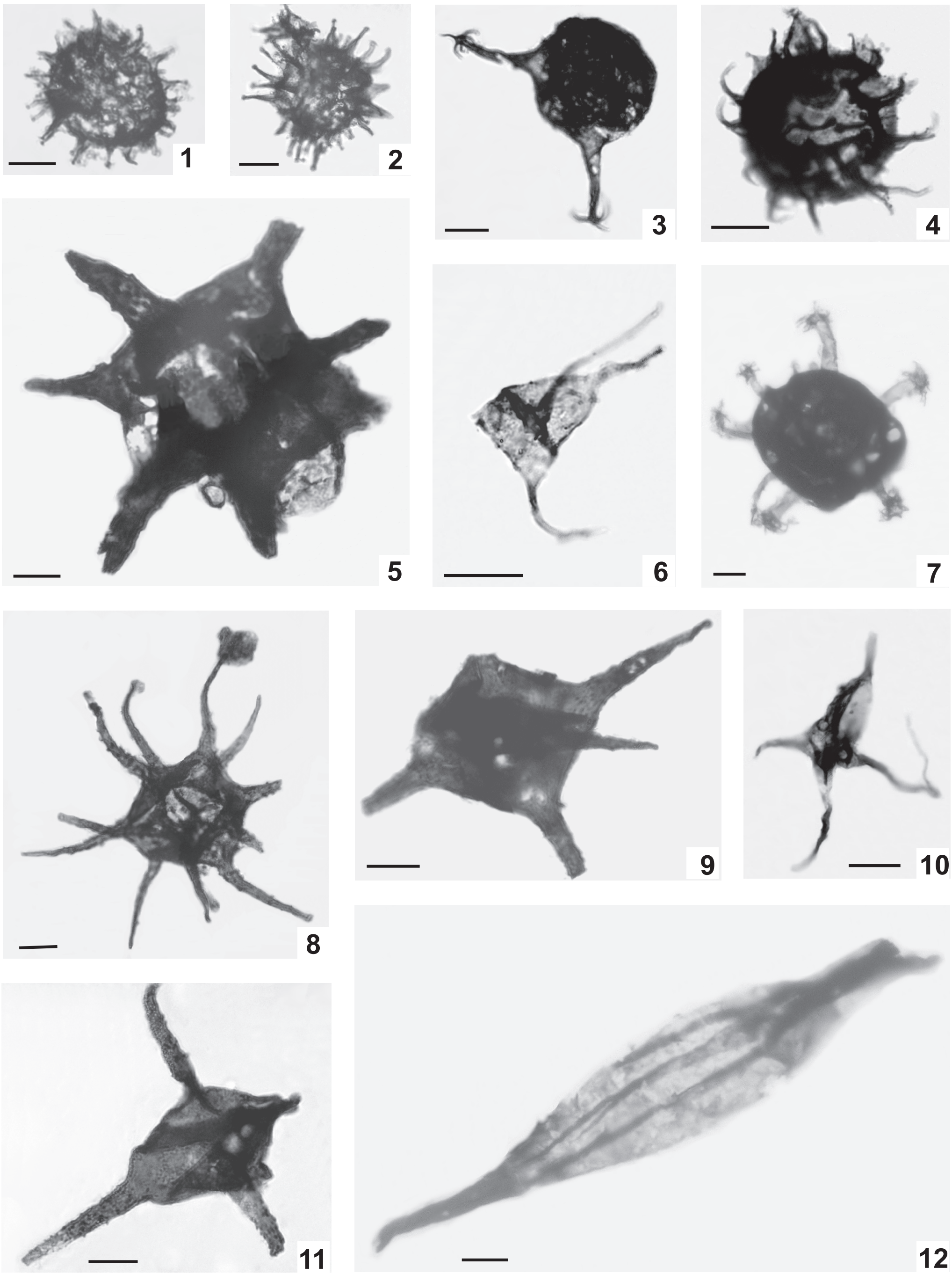


Fig. 3. **1,** *Ammonidium ludloviense* (Lister) Dorning 1981, BA Pal 6005(1) D30/3. **2,** *Ammonidium* sp. cf. *A. waldronense* (Tappan & Loeblich) Dorning 1981, BA Pal 5981 W54/0. **3,** *Ammonidium* sp. A, BA Pal 5988(1) G37/2. **4,** *Barathrisphaeridium?* sp. A, BA Pal 5992(1) Q49/0. **5,** *Barbestiastra barbata* (Downie) Sarjeant & Stancliffe 1994, BA Pal 5992(3) Z57/1. **6,** *Dorsennidium europaeum* (Stockmans & Willièire) Sarjeant & Stancliffe 1994, BA Pal 5988(1) K41/3. **7,** *Cymbosphaeridium* sp. A, BA Pal 5986(2) S62/4 [x0.3]. **8,** *Diexallophasis remota* (Deunff) Playford 1977, BA Pal 5988(1) J51/3. **9,** *Diexallophasis* sp. A, BA Pal 5981(1) E61/4. **10,** *Domasia quadrispinosa* Hill 1974 (Pl. 2, fig. B), BA Pal 5988(1) S55/0. **11,** *Diexallophasis denticulata* (Stockmans & Willière) Loeblich 1970, BA Pal 5988(2) G45/0. **12,** *Eupoikilofusa filifera* (Downie) Dorning 1981, BA Pal 5986(2) F56/2 [x0.5].

Domasia quadrispinosa Hill 1974
(Fig. 3.10)

Dimensions. V∅ = 17(20.5)22 µm, PL = 17(21.7)30 µm (4 specimens measured).
Remarks. We differentiate this species from *Dorsennidium europaeum* (Stockmans & Willièire) Sarjeant & Stancliffe due to the nature of its vesicle (Stockmans & Willièire, 1960; Sarjeant & Stancliffe, 1994). In *D. quadrispinosa* Hill, the vesicle is elongated and inflated, while in *D. europeaum* the vesicle is triangular and flattened.

Genus ***Dorsennidium*** Wicander emend. Sarjeant & Stancliffe 1994

Type species: *Dorsennidium patulum* Wicander 1974.

Dorsennidum europaeum (Stockmans & Willièire) Sarjeant & Stancliffe 1994
(Fig. 3.6)

Dimensions. VØ = 12 µm, PL = 20 µm, PØB = 2 µm (1 specimen measured).

Genus ***Eupoikilofusa*** Cramer 1970a

Type species: *Leiofusa striatifera* (Cramer) Cramer 1970a.
Remarks. The validity of the name *Eupoikilofusa*, as discussed on Dorning (1994), is accepted here.

Eupoikilofusa filifera (Downie) Dorning emend. Mullins 2001
(Fig. 3.12)

1971 *Leiofusa argentina* Pöthe de Baldis: 287, pl. I, fig. 1.
1981 *Eupoikilofusa argentina* (Pöthe de Baldis) Pöthe de Baldis: 239, pl. V, fig. 2.
1987 *Leiofusa argentina* Pöthe de Baldis; Priewalder: 87.
1990 *Leiofusa* cf. *striata* Brito & Santos; Rubinstein: 91, pl. II, fig. 11.
1992a *Leiofusa* cf. *striata* Brito & Santos; Rubinstein: 244-245.
1993 *Leiofusa filifera* Downie, Rubinstein: 71.
1997a *Dactylofusa* cf. *argentina* (Pöthe de Baldis) Pöthe de Baldis: 39, pl. I, fig. 5.
1997 *Dactylofusa striatifera* (Cramer) Fensome *et al.*; Rubinstein: 164, pl. I, fig. 5.

Dimensions. VW = 23(24.8)25 µm, VT = 120(132)150 µm (6 specimens measured).
Remarks. Almost all specimens are incomplete. According to Fensome *et al.* (1990) *Eupoikilofusa filifera* is an invalid combination and it must be referred to *Dactylofusa filifera* (Downie) Fensome *et al.* (1990), however Dorning (1994) made a revision of these generas maintaining as a valid genera *Eupoikilofusa*. The differentiation between *E. sriatifera* and *E. filifera* is based on the number and general characteristics of their striaes. In the first one, striaes appear in a large number, being them thin and discontinuous, while in the second one, the striaes are thick, continuous and there are only between 2 to 5 of them in each individual.

In conformity with this, *Leiofusa argentina* Pöthe de Baldis (1971) is a junior synonym of *E. filifera* not of *E. striatifera* as stated by Priewalder (1987). The material described by Rubinstein (1990), and classified as *L.* cf. *striata* Britos & Santos, could be reubicated as *E. filifera* due to the number (2-4) and characteristics of the striations seen on the illustration of that specimen. The material from La Horqueta Formation categorized as *Dactylofusa striatifera* (Cramer) Fensome *et al.* (Rubinstein, 1997) seem to be *E. filifera* (Downie) Dorning, due to the number of the striations (4) that can be seen in the illustration.

Eupoikilofusa striatifera (Cramer) Cramer 1970
(Fig. 4.1)

1975a *Leiofusa* aff. *striatifera* Cramer; Pöthe de Baldis: 494, pl. III, fig. 9.
1990 *Eupoikilofusa* cf. *striatifera*-complex Cramer & Diez; Rubinstein: 88, figs. 2-3.
1997b *Dactylofusa striatifera* (Cramer) Fensome *et al.*; Pöthe de Baldis: 468, pl. IV, fig. 11.

Dimensions. VW = 20(23.5)28 µm, VT = 128(141.7)150 µm (10 specimens measured).
Remarks. *Eupoikilofusa striatifera* (Cramer) Cramer 1970 differs from *E. filifera* Downie (1959) in the number of striations they have. The latter has between 2 and 5, while the former has 8 or more. *Leiofusa estrecha* Cramer (1964a) is similar in size to *E. striatifera* but the former has a psilated eylima.

Eupoikilofusa* sp. cf. *E. tenuistriata (Pöthe de Baldis) Pöthe de Baldis 1981
(Fig. 4.2)

Description. Vesicle hollow, fusiform with one side convex and the other side straight to slightly concave. A short process arises from each pole of the vesicle. Processes are hollow, open to vesicle cavity and simple. They are preferentially displaced to the straighter side of the vesicle. No excystment method observed.

Dimensions. VL = 53(56)60 μm, VW = 23(23.5)24 μm, PL = 28(29)30 μm (2 specimens measured).

Remarks. The striations on the surface of the vesicle of this species are inconspicuous due to the preservational state of the material. As a result of that, a more accurate assignation is impossible to be made. *Eupoikilofusa* cf. *tenuistriata* (Pöthe de Baldis) Pöthe de Baldis (1981) is similar in shape and dimension to the specimens described here, but in that case, striations present small grana regullary placed on them. *Eupoikilofusa striatifera* Cramer (1964a) differs in having a larger vesicle and more notorious striations, and *E. filifera* Downie (1959) has fewer striations and is larger. *Leiofusa estrecha* Cramer (1964a) differs in having a vesicle with two convex sides and a not ornamented wall. *Dactylofusa cantabrica* Cramer emend. Fensome *et al.* (1990) is similar is size and shape to this specimen, but differs in its ornamentation being fossulate instead of striated (Cramer, 1964a).

Genus ***Gorgonisphaeridium*** Staplin *et al.* emend. Kiryanov 1978

Type species: *Gorgonisphaeridium winslowlii* Staplin *et al.* 1965.

Gorgonisphaeridium* sp. cf. *G. succinum Lister 1970
(Fig. 4.3)

Description. Vesicle hollow, spherical, evenly covered with relatively short, tapering, flexible processes. Processes apparently solid, closed to vesicle interior, acuminated or bifurcated up to the second order. No excystment structure observed.

Dimensions. V∅ = 23(27.6)32 μm, PN = 15(21)30, PL = 5(8)11 μm, P∅B = 1(1.2)2 μm, PL/V∅ = 0.2(0.3)0.4 (26 specimens measured).

Remarks. The bad state of preservation in which the material is found prevents from identifying some of the distinctive characteristics of the species, especially those concerning vesicle ornamentation and wall thickness. *Gorgonisphaeridium? listeri* forma *listeri* Mullins (2001) is similar in size to *G.* sp. cf. *G. succinum* Lister, but differs from it in processes length (in the former are shorter, between 1-6 μm) and branching pattern (in *G. listeri* forma *listeri* processes are acuminated or showing distal branching). *Gorgonisphaeridium citrinum* Downie emend. Mullins (2001) has shorter processes (around 0.7-3 μm); and *G. spinosum* Pöthe de Baldis (1974) is differentiate from *G.* sp. cf. *G. succinum* found on the base-width of their processes -being wider in the first one- an overall smaller size (20-22 μm), and the fact that *G spinosum* show only one order of ramification.

Genus ***Leiofusa*** Eisenack emend. Cramer 1970

Type species: *Leiofusa fusiformis* (Eisenack) Eisenack 1938.

Leiofusa bernesgae Cramer 1964a
(Figs. 4.5, 7.6)

1965 *Leiofusa bispinosoides* Britos & Santos: 10-11, 18, pl. 1, fig. 8.
1971 *Leiofusa banderilla* (sic) Cramer; Pöthe de Baldis: 287, pl. I, fig. 6.
1975a *Leiofusa* cf. *bernesgae* Cramer; Pöthe de Baldis: 493, pl. III, figs. 1-2, 4.
1990 *Leiofusa* cf. *bernesgae* Cramer; Rubinstein: 90, pl. I, figs. 13-14, 17.

Dimensions. VL = 24(26.3)30 μm, VW = 12(16.8)20 μm, VT = 69(106)144 μm, PL = 24(40.1)62 μm, VW/VL = 0.57(0.69)0.87 (6 specimens measured).

Remarks. *Leiofusa bispinosoides* Brito & Santos (1965) is considered to be a junior synonym of *L. bernesgae* by Moreau-Benoit (1974). The differences in size of the material described by Pöthe de Baldis (1975a) and Rubinstein (1990) are not enough criteria to separate these materials from *L. bernesgae*, as stated also by Rubinstein (1992b). *Leiofusa "banderilla"* Cramer, described by Pöthe de Baldis (1971), showed all the distinctive characteristics (shape and size of the vesicle, length of the processes) of *L. bernesgae*, consequently it becomes reassigned here. *Leiofusa banderillae* Cramer (Pöthe de Baldis, 1987) has the appearance of being a specimen of *L. bernesgae*, but both processes are broken, making such designation impossible. The original material of *L. banderillae* Cramer (1964a) has longer processes (between 100-150 μm).

Leiofusa estrecha Cramer 1964a
(Fig. 4.4)

Dimensions. VT = 120(158.3)225 μm, VW = 25(26)35 μm, VW/VT = 0.11(0.17)0.28 (8 specimens measured).

Remarks. All specimens are incomplete. *Leiofusa fusiformis* Eisenack (1934) presents a pilome and a different shape of the processes; *L. parvitatis* Loeblich (1970) is smaller (the overall length varies from 50 to 93 μm). *Eupoikilofusa filifera* (Downie) Dorning (1981) and *E. striatifera* (Cramer) Cramer (1970a) are similar in size, but both present striations (or folds) on their surface. *Eupoikilofusa tenuistriata* (Pöthe de Baldis) Pöthe de Baldis (1981) presents subtle striations on its wall and has a different vesicle shape.

Leiofusa exilata Dorning 1981
(Fig. 4.6)

Dimensions. VW = 13(14.7)18 μm, VT = 100(184.3)263 μm, VW/VT = 0.05(0.10)0.18 (3 specimens measured).
Remarks. Despite the fact that *Leiofusa exilata* Dorning (1981) is smaller in width than the specimens described here, we assigned it to this species based on the similarities both share in length, general shape and relation: vesicle width/total length. *Leiofusa exilata* is also similar in size to *L. estrecha* Cramer (1964a), differing from it the overall shape and the width/total length relationship.

Leiofusa parvitatis Loeblich 1970
(Fig. 4.11)

Dimensions. VL = 19(21)24 μm, VW = 9(9.8)12 μm, PL = 18(29.3)40 μm, VT = 57(79.5)104 μm, VW/VL = 0.4-0.5 (4 specimens measured).
Remarks. *Leiofusa estrecha* Cramer (1964a) is larger (overall length varies between 120-400 μm). *Eupoikilofusa filifera* (Downie) Dorning (1981) is also larger and displays between 3-5 thickenings on its surface.

Leiofusa tumida Downie 1959
(Fig. 4.7)

1990 *Leiofusa* cf. *tumida* Downie; Rubinstein: 91, pl. II, fig. 9.

Dimensions. VL = 20(23)25 μm, VW = 14(16.2)20 μm, PL = 34(40)50 μm, VT = 95(103)125 μm, VW/VL = 0.7-0.8 (3 specimens measured).
Remarks. *Leiofusa* cf. *tumida* Downie as described by Rubinstein (1990) is smaller (total length is 60 μm), but the difference in size is not enough criterions to substantiate its separation.

***Leiofusa* sp. A**
(Fig. 4.8)

1975a *Leiofusa* aff. *estrecha* Cramer; Pöthe de Baldis: 494, pl. III, figs. 3, 7.
1981 *Leiofusa banderillae* Cramer, Pöthe de Baldis: 244, pl. V, fig. 8.
1990 *Leiofusa* sp. A Rubinstein: 91, pl. I, fig. 15.
1997a *Leiofusa tumida* Downie; Pöthe de Baldis: 46, pl. I, fig. 17.
1998 *Leiofusa bernesgae* Cramer; Pöthe de Baldis: 10, pl. 3, fig. 7.

Description. Vesicle slightly rectangular, elongated with a process at each pole. Processes are solid and the contact process-vesicle is indistinct. Eylima thin and laevigated. No excystment method observed.
Dimensions. VL = 30(33)36 μm, VW = 7 μm, VW/VL = 0.23-0.19 (2 specimens measured).
Remarks. In all the observed individuals processes were broken, making a more accurate assignation impossible. The specimens illustrated by Pöthe de Baldis (1975a, 1981, 1997a, 1998) as *Leiofusa* aff. *estrecha, L. banderillae, L. tumida,* and *L. bernesgae* respectively, display all the characteristics of the species described here. *Leiofusa* sp. A differs from *L. bernesgae* Cramer (1964a) and *L. tumida* Downie (1959) in the shape of the vesicle (which is cylindrical to rectangular in the former) and the nature of its processes (which are solid). It can be distinguished from *L. estrecha* based on its size (being the latter much larger, with overall lenghts that varies from 120 to 400 μm) and from *L. banderillae* Cramer (1964a) contrasting the length (around 100-150 μm) and nature of the processes, as well as the shape of the vesicle.

Genus ***Micrhystridium*** Deflandre emend. Sarjeant & Stancliffe 1994

Type species: *Micrhystridium inconspicuum* Deflandre 1935.

Micrhystridium* sp. cf. *M. stellatum Deflandre 1945
(Fig. 4.10)

Description. Vesicle originally spherical, but polyhedral in shape, bearing numerous (12-20) simple spines. Spines are slender, hollow and communicate freely with the vesicle cavity. Distal tips are simple and closed. Processes bases are wide, which gives the polyhedral shape in compression. Eylima laevigate and thin. No excyst-

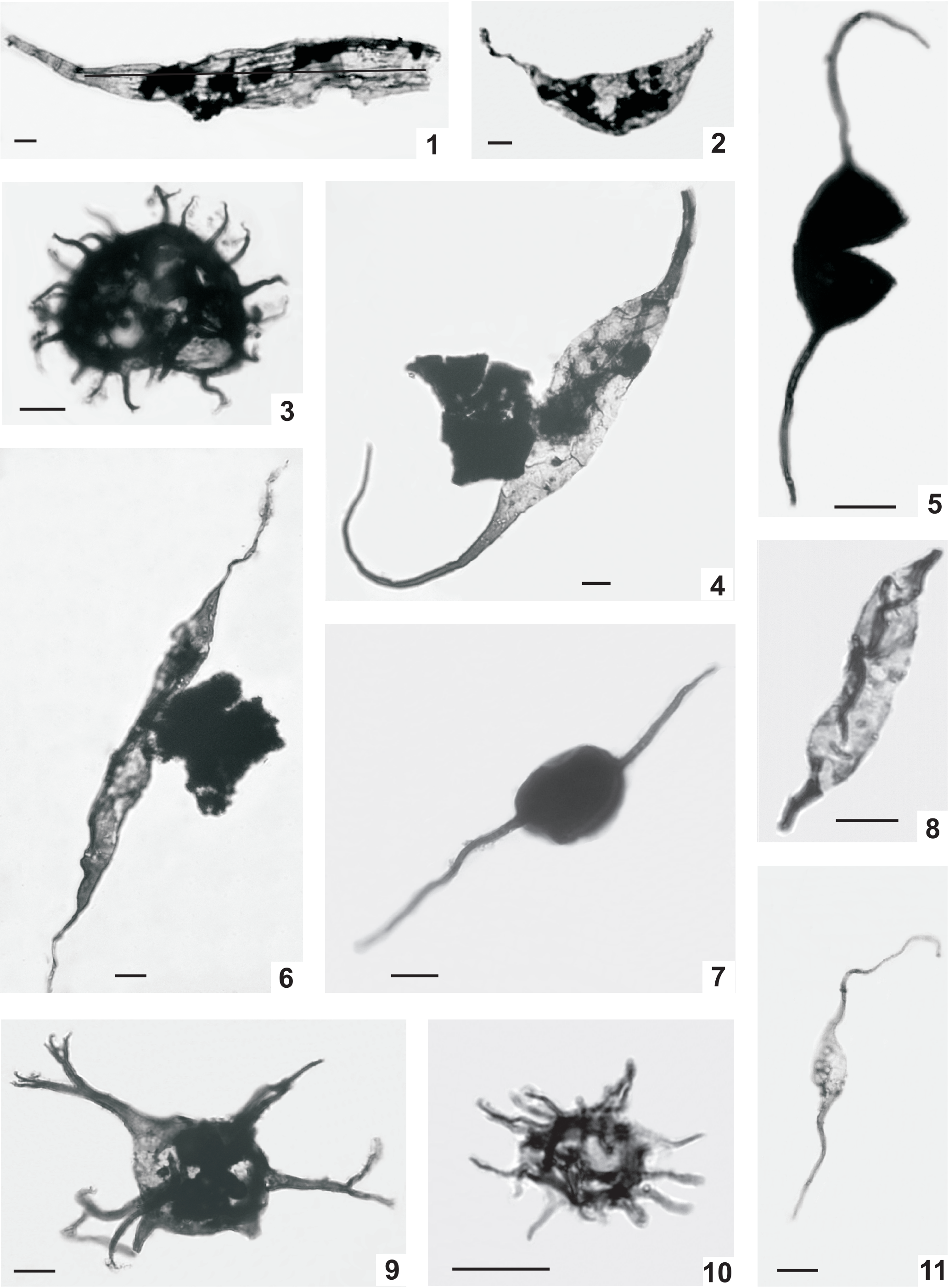


Fig. 4. **1,** *Eupoikilofusa striatifera* (Cramer) Cramer 1970a BA Pal 5984(2) J44/3 [x0.5]. **2,** *Eupoikilofusa* sp. cf. *E. tenuistristra* (Pöthe de Baldis) Pöthe de Baldis 1981 BA Pal 5984(2) Q68/2 [x0.5]. **3,** *Gorgonisphaeridium* sp. cf. *G. succinum* Lister 1970 BA Pal 5992(2) L52/2. **4,** *Leiofusa estrecha* Cramer 1964a BA Pal 5994(2) F49/3 [x0.5]. **5,** *Leiofusa bernesgae* Cramer 1964a BA Pal 5992(2) L60/0. **6,** *Leiofusa exilata* Dorning 1981 BA Pal 5994(2) P56/4. **7,** *Leiofusa tumida* Downie 1959 BA Pal 5992(2) D34/2. **8,** *Leiofusa* sp. A BA Pal 6007(1) O30/0. **9,** *Multiplicisphaeridium arbusculum* Dorning 1981 BA Pal 5992(1) A43/3. **10,** *Micrhystridium* sp. cf. *M. stellatum* Deflandre 1945 BA Pal 6005(1) Q28/0. **11,** *Leiofusa parvitatis* Loeblich 1970 BA Pal 5992(3) K41/4.

ment structure observed.

Dimensions. V∅ = 13(13.5)14 μm, PL = 5(6)7 μm (2 specimens measured).

Remarks. The assignment of these specimens to *Micrhystridium stellatum* Deflandre (1945) is doubtfully since we only have two individuals, in which not all the determinant characteristics of the species could be seen.

Genus ***Multiplicisphaeridium*** Staplin emend. Lister 1970

Type species: *Multiplicisphaeridium ramispinosum* Staplin 1961.

Multiplicisphaeridium arbusculum Dorning 1981

(Fig. 4.9)

1974 *Multiplicisphaeridium ramusculosum* Deflandre; Pöthe de Baldis: 318, pl. IV, fig. 5.

Dimensions. V∅ = 20(25)30 μm, PL = 23(27.3)31 μm, P∅B = 2 μm, PN = 6-11 (3 specimens measured).

Remarks. The material described as *Multiplicisphaeridium ramusculosum* Deflandre by Pöthe de Baldis (1974) display wide variations in the branching pattern. According to the characteristics depict by Fig. 5 -the presence of processes both acuminated and bifurcated and the fact that such bifurcations take place at half of the processes' length- we consider proper to reassign such material to *M. arbusculum*. *Multiplicisphaeridium ramusculosum* Lister (1970) processes bifurcate only distally.

***Multiplicisphaeridium baldisii* sp. nov.**

(Figs. 5.1-3, 7.9)

1974 *Multiplicisphaeridium ramusculosum* Deflandre; Pöthe de Baldis: 318, pl. IV, fig. 3.

2000 *Evittia? escobaides* Cramer emend. Sarjeant & Vavrdová; Pöthe de Baldis: 332, pl. 3, fig, D.

Occurrence. Cachipunco Formation, Angosto Los Pereyras Section, BA Pal 5980-5992; Cumbres Los Pereyras Section, BA Pal 6004, 6006.

Type location. Angosto los Pereyras, Jujuy Province, Argentina.

Stratotype. Cachipunco Formation.

Diagnosis. Vesicle spherical, hollow, with heteromorphic processes. Eylima thick, scabrate to laevigate. Up to 13 processes, short, conical to tubiform, hollow and freely communicated with vesicle interior. Processes show different branching patterns: distally bifurcated of one bifurcation at 2/3rds of the processes length and a second one at their distal ends.

Holotype. BA Pal 5988 (1) O71/1 (Fig. 5A).

Name derivation. It is named in honor to Elba Diana Pöthe de Baldis, Argentinian palynologist.

Description. Vesicle spherical, hollow, with evenly distributed, slightly heteromorphic processes. Eylima thick (1 mm), scabrate to laevigate, and in some specimens slightly costate at processes bases. 6-13 sub conical to tubiform, hollow, freely communicated with vesicle interior, short (*ca.* ½ vesicle diameter) processes, with laevigate to slightly granulate walls. Processes show different branching patterns, some bifurcate distally, while others show a first bifurcation at 2/3rds of the processes length and a second one at their distal ends. An excystment structure is not observed.

Dimensions. VD = 24(28.8)33 μm, PL = 11(14.6)19 μm, PDB = 3(4.1)5 μm (25 specimens measured).

Remarks. This species is characterized by the shape and width of its processes, the variations in the ramification patterns and the lack of conspicuous ornamentation. The characteristics exhibit by the material described as *Multiplicisphaeridium ramusculosum* Deflandre by Pöthe de Baldis (1974) -wide processes and a conspicuous ramification pattern– allow their reinterpretation as *M. baldisii* sp. nov. *Multiplicisphaeridium ramusculosum* has longer and slender processes than *M. baldisii*. Pöthe de Baldis (2000) assigned individuals similar to *M. baldisii* to the specie *Evittia escobaides* (Cramer 1964b), but the latter has a polygonal vesicle and presents only one order of branching, characteristics that clearly distinguish both species.

Multiplicisphaeridium picorricum (Cramer) Lister has a larger number of processes (around 15-20), which are thinner than those of *M. baldisii* (Cramer, 1964b). *Multiplicisphaeridium robertinum* (Cramer, 1964b; Lister, 1970) in having more narrow processes, and a thinner eylima than *M. baldisii*.

Multiplicisphaeridium baldisii is differentiated from *M.* sp. A, as described on this work, based on the length, shape and number of the processes. It differs from *M.* sp B in the pattern of ramification of the processes. It is separated of *M.* sp C due to the shape of the processes, being in the latter mucho wider at the base, and presenting high-angled bifurcations. Also, *M.* sp. C has distally solid pinnulas.

Multiplicisphaeridium eoplancktonicum

(Eisenack) Lister 1970

(Fig. 5.4)

1998 *Oppilatala eoplactonica* (Eisenack) Dorning; Pöthe de Baldis: 14, pl. IV, figs. 10-11.

Dimensions. VØ = 38 μm, PL = 43 μm, PN = 7 (1 specimen measured).

Remarks. Dorning (1981) transferred *Multiplicisphaeridium eoplactonicum* (Eisenack) Lister to *Oppilatala* Loeblich & Wicander emend. Sarjeant & Vavrdová (1997). The main characteristic to differentiate both genera is the nature of their processes. In *Oppilatala*, processes do no communicate freely with the vesicle interior since their bases have a basal plug, while in *Multiplicisphaeridium* are open to the vesicle cavity. So, if the original holotype of *M. eoplanctonicum* has their processes in free communication with the vesicle interior, as it is described, the assignment of this specie to the genus *Oppilatala* would be erroneous. Consequently, the assignment of this specie to the genus *Multiplicisphaeridium* is based on the fact that the processes are open to the vesicle interior. *Multiplicisphaeridium eoplancktonicum* differs from *M. arbusculum* Dorning (1981) in having a distinct branching pattern, in the former is irregular, while in the latter, the processes branch dichotomously several times. *Multiplicisphaeridium ramusculosum* Lister (1970) has processes that branched distally.

Multiplicisphaeridium ramusculosum

(Deflandre) Lister 1970

(Fig. 5.6)

Dimensions. VØ = 22(26.3)29 μm, PL = 21(22.3)23 μm, PN = 10(12.2)16 (3 specimens measured).

Remarks. *Multiplicisphaeridium arbusculum* Dorning (1981) has fewer processes (6-12) and they branched between one third and half of the length of the processes. It differs from *M.?* cf. *eoplactonicum* (Eisenack) Lister (1970) in number (4-5) and length of the processes (45 μm in the holotype).

Multiplicisphaeridium variabile (Lister)

Dorning 1981

(Fig. 5.7)

Dimensions. VØ = 22(26.3)28 μm, PL = 21(22.3)23 μm, PØB = 3 μm, PN = 10(11)12; 10-11 processes (3 specimen measured).

Remarks. *Multiplicisphaeridium osgoodense* (Cramer & Díez) Eisenack *et al.* (1973) also has a polygonal vesicle, but it is larger (25-50 μm) and has fewer processes (around 6). *Multiplicisphaeridium pentagonale* (Stockmans & Williérie) Mullins (2002) has fewer processes and some of them are simple. The polygonal vesicle distinguishes *M. variabile* from the other species of *Multiplicisphaeridium*.

Multiplicisphaeridium* sp. cf. *M. jarillense

Pöthe de Baldis 1997b

(Fig. 5.5)

Description. Vesicle spherical, hollow, laevigate, with a thin wall. 9-17 hollow, open to vesicle cavity, laevigate processes. Processes are relatively long (around 50% of the vesicle diameter), slender and flexuous. Distally they multifurcate in an irregular fashion. No excystment method observed.

Dimensions. V∅ = 16(17.6)19 μm, PL = 4(7)12 μm (10 specimens measured).

Remarks. The assignment of these specimens to *Multiplicisphaeridium jarillense* Pöthe de Baldis (1997b) is based on the similarity in number and character of the processes, and in a similar relationship length of the processes/vesicle diameter. Owing to the bad state of preservation of the material is impossible to make a more exact assignment. *Oppilatala ramusculosa* (Deflandre) Dorning (1981) is quite similar to our specimen, but the former its processes do not communicate with the vesicle interior. *Multiplicisphaeridium* sp. cf. *M. jarillense* Pöthe de Baldis differs of *M. eoplanctonicum* (Eisenack) Lister (1970) in having more processes and a smaller relationship length of the process/vesicle diameter (being the processes of the latter almost twice as large as the vesicle). *Multiplicisphaeridium cladus* (Downie) Eisenack (1969) has a similar size and number of processes, but the branching pattern is different (wide bifurcation angle, and it may present processes distally trifurcated). *Multiplicisphaeridium paraguaferum* (Cramer) Lister (1970) has more processes (more than 20). *Multiplicisphaeridium intonsurans* (Lister) Sarjeant & Stancliffe (1994) differs in the branching pattern (processes are barbate) and in the shape of the vesicle which is slightly polygonal. *Multiplicisphaeridium variopinnum* Cramer (1966) display processes which are simple or monofurcate. It differs from *M. forquiferum* (Cramer & Díez) Eisenack *et al.* (1973) in having a distinct differentiation between the processes and the vesicle.

M*ultiplicisphaeridium ramispinosum* (Staplin) Sarjeant & Vavrdová (1997) processes bifurcate dichotomously, has a slightly larger vesicle, and longer processes.

***Multiplicisphaeridium* sp. A**

(Fig. 5.8)

Description. Vesicle spherical, to slightly ellipsoidal in shape, laevigate, single-layered, with 4-6 hollow, long, psilated processes. Processes communicate freely with vesicle interior. Branching occurs 1/2 to 2/3rds of the processes length. Branches ramified up to the third order. No excystment method observed.

Dimensions. VØ = 24(27.3)34 μm, PL = 22(24.1)35 μm, PØB = 3(4.2)5 μm, PN = 4-6 (7 specimens measured).

Remarks. It differs from *Multiplicisphaeridium arbusculum* Dorning (1981) in having fewer processes; *M. ramusculosum* Lister (1970) has a distinct branching pattern.

***Multiplicisphaeridium* sp. B**

(Fig. 5.9)

Description. Vesicle spherical to subspherical, hollow, thin-walled and covered with 12-20, evenly distributed, rather columnar processes. Processes bifurcate distally only once, are open to vesicle cavity, and are hollow though distally they are solid. Excystment by unornamented rupture of vesicle wall.

Dimensions. VØ = 20(25.3)35 μm, PL = 5(8)13 μm, PN = 11(15)20 (3 specimens measured).

Remarks. We assigned these specimens to the genus *Multiplicisphaeridium* Staplin emend. Lister because its processes present a single bifurcation distally, while in *Ammonidium* Lister processes equifurcate, being into two or more distally and flexible spines. It is differentiate from the other species of *Multiplicisphaeridium* described here due to the nature of its ramification pattern.

***Multiplicisphaeridium* sp. C**

(Fig. 5.12)

Description. Vesicle spherical, laevigated, single-layered, moderate thick-walled, 8-16 tapering, heteromorphic, open to vesicle cavity processes. Processes are hollow but distal pinnulae are solid, and may present branches up to the 4th order. Branching occurs between 2/3rds and half the way of the processes length. No excystment opening has been observed.

Dimensions. VØ = 16(20.4)25 μm, PL = 6(9.4)16 μm, PØB = 2(2.8)5 μm, PN = 8(9.2)16 (5 specimens measured).

Remarks. *Multiplicisphaeridium snigirevskaiae* (Stockmans & Willèrie, 1963; Fensome *et al.,* 1990) is similar in size and pattern of branching, but it has a hexagonal vesicle. It differs from *M. pardaminum* Díez & Cramer (1976) in having shorter processes and another branching style. *Multiplicisphaeridium fermosum* Cramer (1970) has ramifications up to the 3rd order, and present a slightly different ramification pattern. *Multiplicisphaeridium ramusculosum* Lister (1970), *M. arbusculum* Dorning (1981), and *M. eoplanctonicum* (Eisenack) Lister (1970) have more flexible, longer and slender processes. It is differentiate from all the other species described here due to the characteristics of its processes (base diameter and ramification pattern). A more exact assignation could not be made due to the state in which the material is found.

Genus ***Neoverhyachium*** Cramer emend.
Sarjeant & Stancliffe 1994

Type species: *Neoveryhachium carminae* (Cramer) Cramer 1970.

Neoveryhachium carminae Cramer 1970

(Figs. 5.10-11)

1998 *Neoveryhachium*? sp. Pöthe de Baldis: 12, pl. IV, fig. 7.

1998 *Veryhachium valiente* Cramer; Pöthe de Baldis: 17, pl. V, figs. 8, 18.

Dimensions. VL = 16(19.9)24 μm, VW = 11(14.7)18 μm, PL = 10(16.6)30 μm, P∅B = 1.5(2.0)3 μm (23 specimens measured).

Remarks. *Neoveryhachium mayhillensis* Dorning (1981) is larger than *N. carminae* Cramer. According to Mullins (2001) *N. carminae* has also a more complex pattern of folds. Due to a preservation bias, not all the individuals observed here show the pattern of folds. The specimens described by Pöthe de Baldis as *N.?* sp. (Pöthe de Baldis, 1998) and *Veryhachium valiente* Cramer (Pöthe de Baldis, 1998) are very similar to the specimens assigned here to *N. carminae*. It has similar dimension of vesicle and processes. The absence of the characteristic fold of *Neoveryhachium* may be due to a preservation bias.

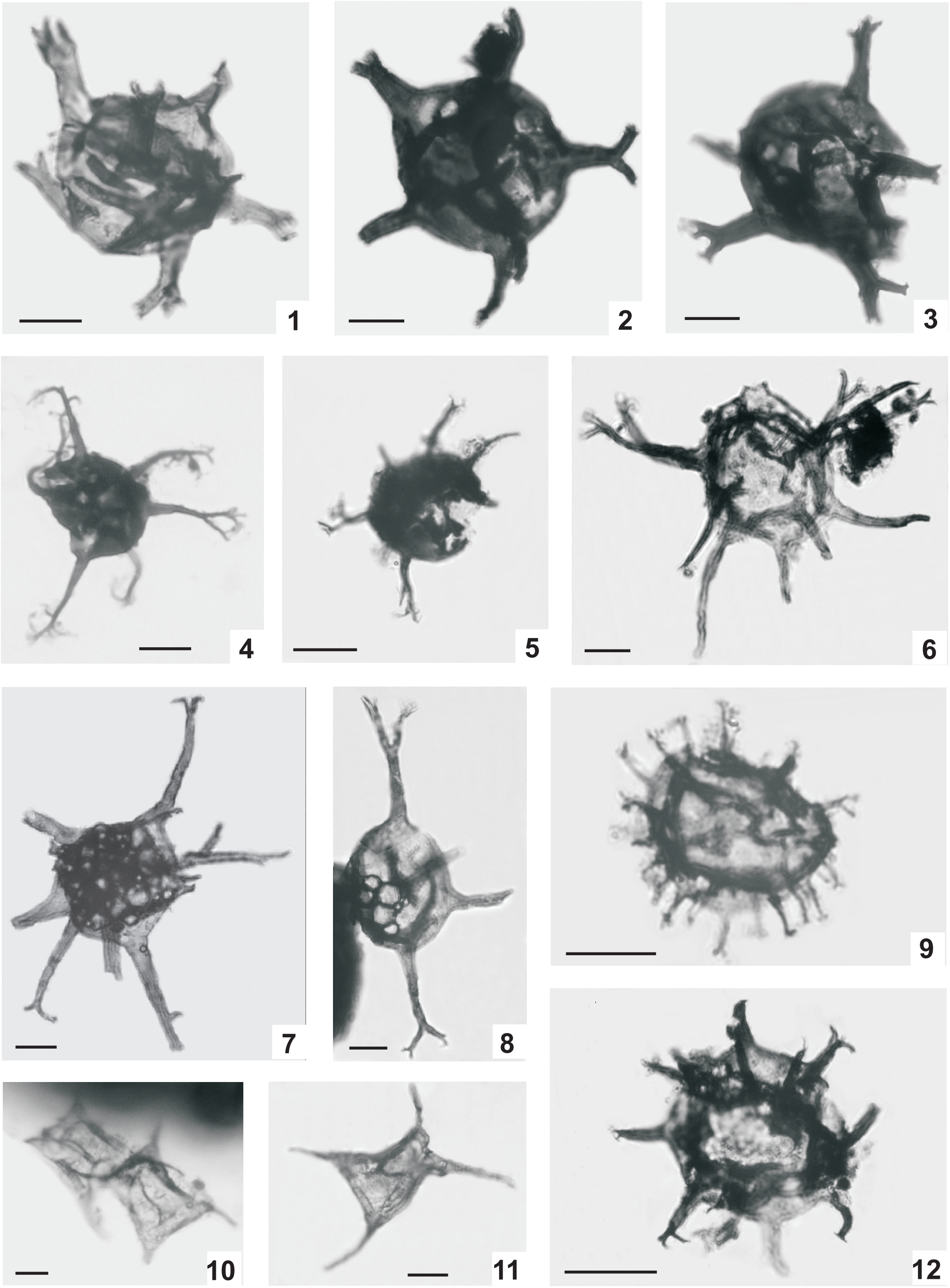


Fig. 5. **1-3,** *Multiplicisphaeridium baldisii* sp. nov.**, 1,** holotype, BA Pal 5988(1) O71/1; **2,** BA Pal 5988(2) P43/0; **3,** BA Pal 5992(2) C52/1. **4,** *Multiplicisphaeridium eoplanctonicum* (Eisenack) Lister 1970 BA Pal 5992(4) B52/1 [x0.5]. **5,** *Multiplicisphaeridium* sp. cf. *M. jarillense* Pöthe de Baldis 1997b BA Pal 5988(2) F45/0. **6,** *Multiplicisphaeridium ramusculosum* (Deflandre) Lister 1970 BA Pal 5992(2) E53/2. **7,** *Multiplicisphaeridium variabile* (Lister) Dorning 1981 BA Pal 5992(3) Q48/3. **8,** *Multiplicisphaeridium* sp. A BA Pal 5992(3) E59/4. **9,** *Multiplicisphaeridium* sp. B BA Pal 6005(1) R35/2. **10-11,** *Neoveryhachium carminae* Cramer 1970a, **10,** BA Pal 5991 Y49/1; **11,** BA Pal 5988(1) S69/3. **12,** *Multiplicisphaeridium* sp. C BA Pal 5991 G39/0.

Genus ***Onondagaella*** Cramer emend. Playford 1977

Type species: *Veryhachium asymmetricum* Deunff 1954 (a *nomen nudum* until validated by Deunff, 1961).

Onondagaella asymmetrica (Deunff) Cramer 1966
(Figs. 6.1, 7.4)

Dimensions. VL = 40(59.7)82 μm, PL = 10(21.6)30 μm (50 specimens measured).
Remarks. The vesicle length was measured from the broader process to the opposite size. Processes length is measured in the two identical processes.

Genus ***Ozotobrachion*** Loeblich & Drugg 1968

Type species: *Ozotobrachion dactylos* Loeblich & Drugg 1968.

***Ozotobrachion* sp. A**
(Fig. 6.6)

Description. Vesicle triangular in outline, cushion-like, with convex sides and three processes, one arising from each corner of the vesicle. Processes tubiform, flexible, hollow, not communicated with vesicle interior, with blunt or stub distal ends. No excystment structure observed.
Dimensions. VØ = 17(21.5)26 μm, PL = 12(18)25 μm, PØ = 2(3)4 μm (5 specimens measured).
Remarks. *Triangulina* Cramer (1964b) and *Ozotobrachion* Loeblich & Drugg (1968) are the two genera that posses a triangular vesicle and a double-layered wall. *Ozotobrachion* has processes with bifurcated distal ends, while in *Triangulina* processes have rounded distal ends. In the individuals recorded in Angosto Los Pereyras Section, distal ends are broken; therefore a more accurate assignment could not be made. Despite of that, and owing to the fact that *Ozotobrachion* has usually longer processes than *Triangulina*, we decided to assign these specimens to the former genus, instead of the latter.

Genus ***Salopidium*** Dorning 1981

Type species: *Baltisphaeridium brevispinosum* var. *granuliferum* Downie 1959.

Salopidium* sp. cf. *S. granuliferum (Downie) Dorning 1981
(Fig. 6.7)

Description. Vesicle spherical, hollow, with a thick, foveolate wall. Processes are numerous (*ca.*, 25), relatively short (1/3 of the vesicle diameter), slendery columnar, tapering into simple, unbranched tips. Excystment not observed.
Dimensions. V∅ = 25-27 μm, PL = 7-8 μm, P∅B = 2-3 μm (2 specimens measured).
Remarks. Since the small number of specimens present, we uncertainly assigned this species based on the width of its processes, since they are much shorter and broader than in the holotype as described by Mullins (2001).

Genus ***Tylotopalla*** Loeblich emend. Sarjeant & Vavdrová 1997

Type species: *Tylotopalla digitifera* Loeblich 1970.

Tylotopalla maraca Díez & Cramer 1976
(Fig. 6.8)

Dimensions. V∅ = 25 μm, PL = 10 μm (1 specimen measured).
Remarks. The transfer of *Tylotopalla maraca* Díez & Cramer (1976) to the genus *Dorsennidum* Wicander (1974) proposed by Sarjeant & Vavdrová (1997) is not accepted herein since *Dorsennidum* includes forms with polygonal vesicles determined by the acuminated and hollow processes, which range in number between 4-10 (Sarjeant & Stancliffe, 1994). While this species has a spherical vesicle, with 10-30 processes. *Salopidium granuliferum* (Downie, 1959) has a foveolate wall and more and shorter processes. *Ammonidium waldronense* (Tappan & Loeblich, 1971) has small rosette like spines at the processes tips.

Tylotopalla robustispinosa (Downie) Eisenack *et al*. 1973
(Fig. 6.3)

Dimensions. V∅ = 13 μm, PL = 5 μm (1 specimen measured).

Genus ***Veryhachium*** Deunff emend. Sarjeant & Stancliffe 1994

Type species: *Veryhachium trisulcum* (Deunff) Deunff 1954, subsequent designation by Downie (1959) (see Loeblich & Tappan, 1976).

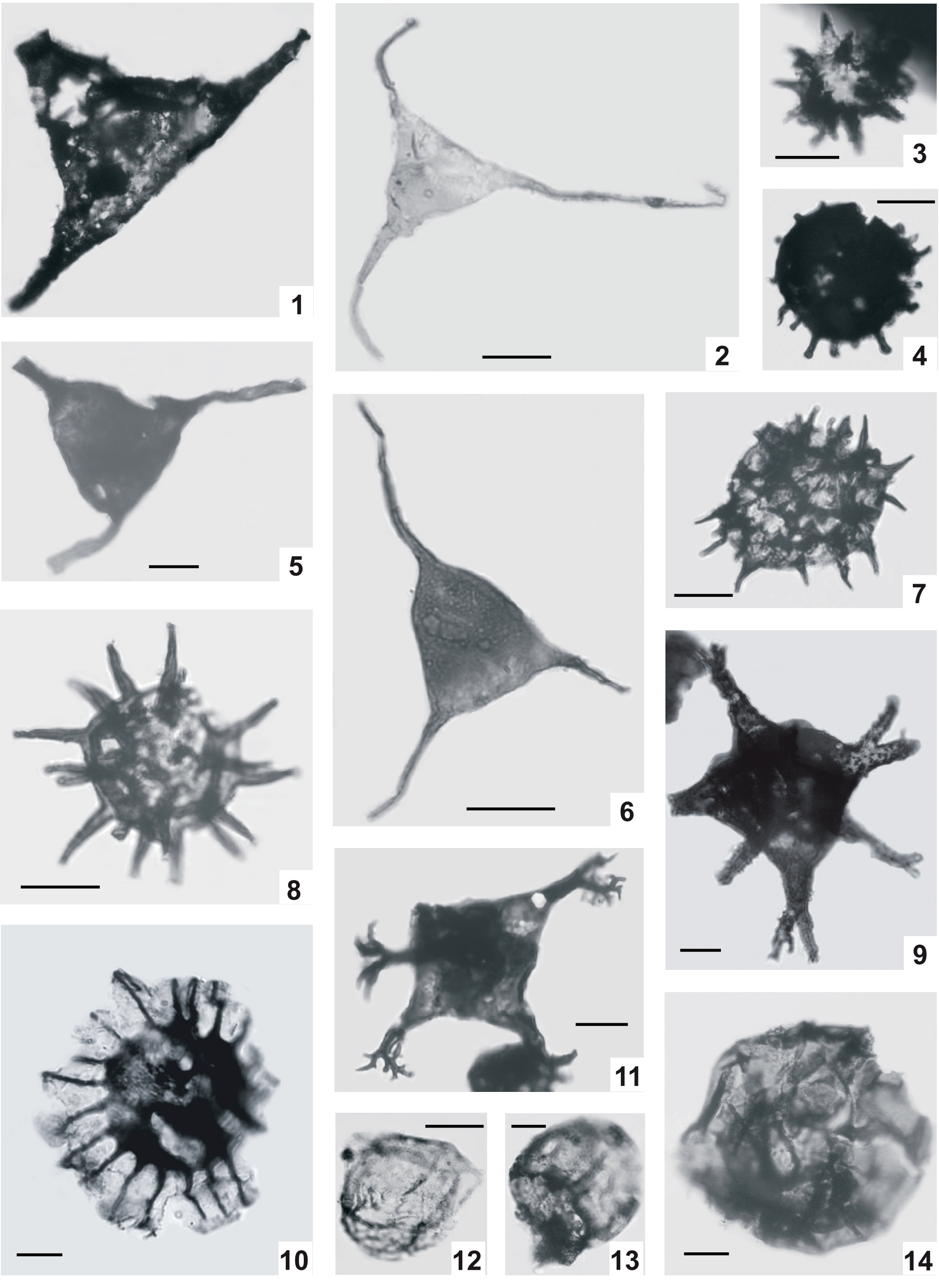


Fig. 6. **1,** *Onondagaella asymmetrica* (Deunff) Cramer 1966 BA Pal 5988(2) F56/0. **2,** *Veryhachium trisphaeridium* Downie 1963 BA Pal 5988(2) L50/1. **3,** *Tylotopalla* sp. cf. *T. robustispinosa* (Downie) Eisenack *et al*. 1973 BA Pal 5992(3) J52/4. **4,** Cf. *Visbysphaera* sp. A BA Pal 5988(2) R56/2. **5,** *Veryhachium trispinosum* (Eisenack) Stockman & Willière 1963 BA Pal 5988(1) J60/0. **6,** *Ozotobrachion* sp. A BA Pal 5988(1) L68/0. **7,** *Salopidium* sp. cf. *S. granuliferum* (Downie) Dorning 1981 BA Pal 6005(2) U28/0. **8,** *Tylotopalla maraca* Díez & Cramer 1976 BA Pal 5981 F29/0. **9,** Acritarca type A BA Pal 5981 W43/1. **10,** *Duvernaysphaera aranaides* (Cramer) Cramer & Díez 1972 BA Pal 5988(1) U57/1. **11,** *Vogtlandia* sp. A BA Pal 39(1) L52/1. **12,** *Leiosphaeridia wenlockia* Downie 1959 BA Pal 5988(2) E52/3. **13,** *Ambitisporites avitus* Hoffmeister 1959 BA Pal 5988(2) H42/1. **14,** *Leiosphaeridia* sp. A BA Pal 5992(3) G34/2.

Veryhachium trisphaeridium Downie 1963
(Fig. 6.2)

Dimensions. V∅ = 17(18.3)21 μm, PL = 15(23.1)35 μm, P∅B = 1(1.8)2 μm (16 specimens measured).
Remarks. *Veryhachium trisphaeridium* Downie is very similar to *Dorsennidium europearum* (Downie) Sarjeant & Stancliffe (1994), although the latter has a fourth process arising perpendicular to the plane of the vesicle.

Veryhachium trispinosum (Eisenack) Stockman & Willière 1962
(Figs. 6.4, 7.3)

Dimensions. V∅ = 14(19.8)25 μm, PL = 11(26.4)42 μm (38 specimens measured).
Remarks. *Veryhachium trispinosum* (Eisenack) Stockman & Willière (1962) is differentiated from *V. trisphaeridium* Downie (1963) due to the thickness of its wall and the nature of its processes.

Genus ***Visbysphaera*** Lister emend. Kiryanov 1978

Type species: *Visbysphaera dilatispinosa* (Downie) Lister 1970.

Cf. ***Visbysphaera*** sp. A
(Figs. 6.4, 7.10)

Description. Vesicle spherical, with rather numerous (*ca.,* 14), short, clavate to capitate processes. Excystment structure not observed.
Dimensions. V∅ = 20-31 μm, PN = 6-14, PL = 6-7 μm (2 specimens measured).
Remarks. The genus *Visbysphaera* Lister emend. Kiryanov is characterized by its columnar to club shaped processes and the ornamentation of the vesicle (Lister, 1970). Since in our specimens, this last characteristic is impossible to see due to the state of preservation of the material, we assigned them doubtfully to this genus.

Genus ***Votglandia*** Burmann 1970

Type species: *Votglandia ramificata* Burmann 1970.

Vogtlandia sp. A
(Fig. 6.11)

Description. Vesicle thin, single-walled, scabrate, quadrangular shaped, with straight to slightly convex or concave sides. 5 conical, hollow, open to vesicle interior, multifurcate (at half of the processes length) up to the fourth order processes. Such processes have very broad bases, and modify vesicle shape. No excystment method observed.
Dimensions. V∅ = 22-28 μm, PL = 15-19 μm, P∅B = 6-8 μm (2 specimens measured).
Remarks. These specimens are included in the genus *Vogtlandia* Burmann since the shape of the vesicle, number of processes and ramification pattern (Burmann, 1970). A more accurate designation is impossible to be made due to the state of preservation in which the scarce material is found.

ACRITARCA *INCERTAE SEDIS*

Acritarca type A
(Fig. 6.9)

Description. Vesicle polygonal in outline, formed by the coalescence of 7 to 9 conical processes. The broad-based processes are bifurcated up to three times. The first bifurcation develops at half of the process's length. Vesicle and processes evenly covered with grana and/or spines. No excystment method observed.
Dimensions. VØ = 24-31 μm, PL = 22-24 μm, PØB = 9-10 μm, PN = 7-9 (2 specimens measured).
Remarks. This species is differentiated from *Barbestiastra* Downie emend. Sarjeant & Stancliffe (1994) due to the fact that *Barbestiastra* has acuminate processes while this species present distal ramifications.

Class PRASINOPHYCEAE Christensen 1962

Genus ***Duvernaysphaera*** Staplin emend. Deunff 1964

Type species: *Duvernaysphara tenuicingulata* Staplin 1961.

Duvernaysphaera aranaides (Cramer) Cramer & Díez 1972
(Fig. 6.10)

1971 *Helios aranaides* Cramer; Pöthe de Baldis: 289, pl. II, fig. 8.
1974 *Duvernaysphaera jelinii* Pöthe de Baldis; Pöthe de Baldis: 326, pl. I, fig. 3.
1975a *Duvernaysphaera jelinii* Pöthe de Baldis: 495, pl. IV, fig. 1-2, 4-5.
1975b *Helios aranaides* Cramer; Pöthe de Baldis: 510, pl. III, fig. 6.

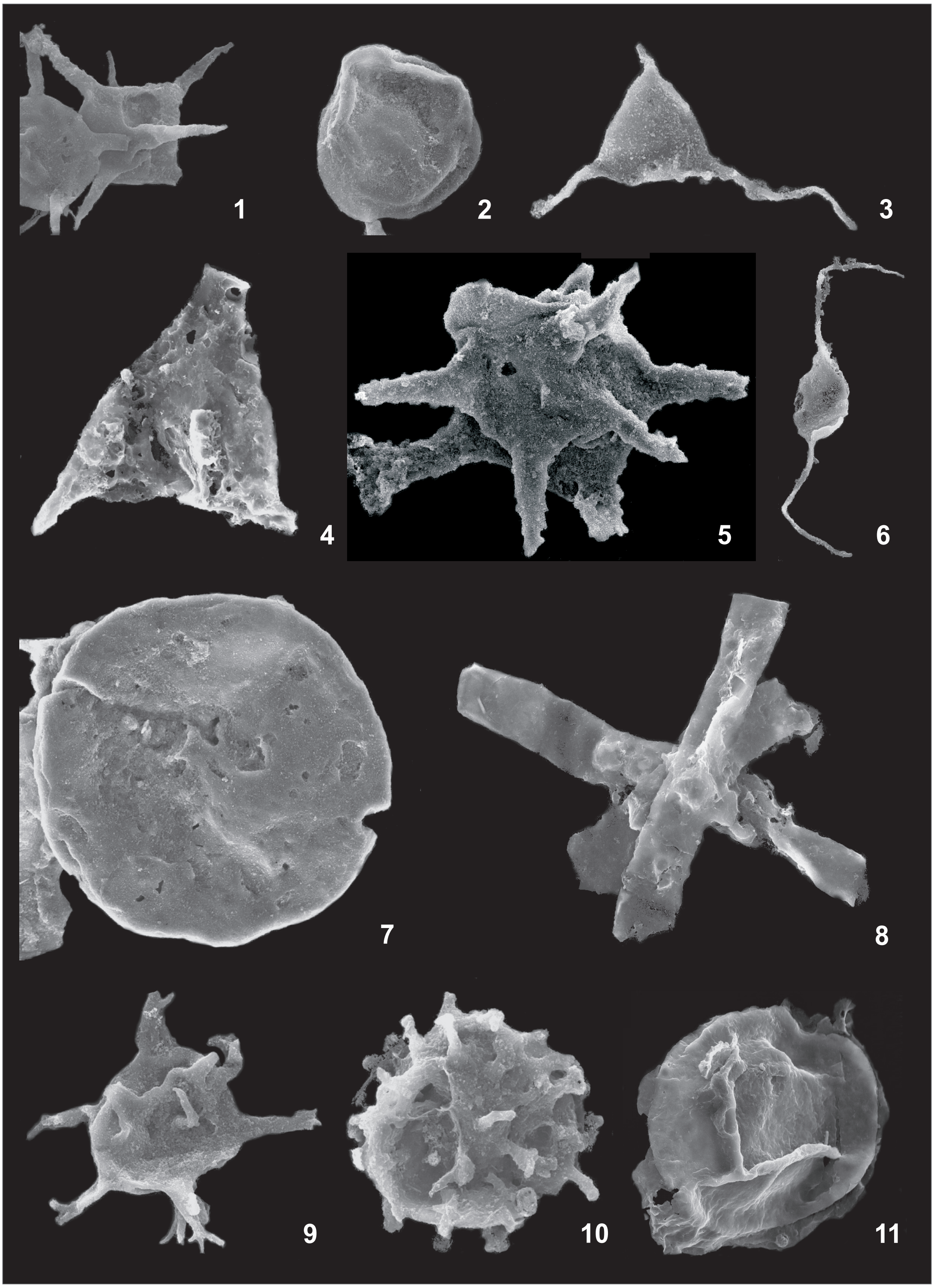


Fig. 7. **1,** *Diexallophasis* sp. A BA Pal 5988. **2,** *Leiosphaeridia wenlockia* Downie 1959 BA Pal 5988. **3,** *Veryhachium trispinosum* (Eisenack) Stockman & Willière 1962 BA Pal 5988. **4,** *Onondagaella asymmetrica* (Deunff) Cramer 1966 BA Pal 5988. **5,** *Barbestiastra barbata* Downie emend. Sarjeant & Stancliffe 1994 BA Pal 5988. **6,** *Leiofusa bernesgae* Cramer 1964a BA Pal 5988. **7,** *Leiosphaeridia* sp. A BA Pal 5988. **8,** *Proteolobus cylindrus* Al-Ruwaili 2000 BA Pal 5988. **9,** *Multiplicisphaeridium baldisii* sp. nov. BA Pal 5988. **10,** Cf. *Visbysphaera* sp. A BA Pal 5988. **11,** Spore type A BA Pal 5988.

1981 *Duvernaysphaera gothica* Martín; Pöthe de Baldis: 239, pl. III, figs. 1-2.
1981 *Helios aranaides* Cramer; Pöthe de Baldis: 243, pl. IV, figs. 10-12.
1987 *Duvernaysphaera gothica* Martin; Pöthe de Baldis: 92, pl. I, fig. 21.
1991 *Helios aranaides* Cramer; Rubinstein: 97, pl. I, figs. 2-3, 6-7.
1991 *Duvernaysphaera gothica* Martin; Rubinstein: 97, pl. I, figs. 1, 4-5.
1992a *Helios aranaides* Cramer; Rubinstein: 238, pl. II, fig. 3.
1993 *Duvernaysphaera gothica* Martin; Rubinstein: 70.
1993 *Helios aranaides* Cramer; Rubinstein: 70.

Dimensions. T = 36(36.7)49 μm, ∅C = 17(20)28 μm, PL = 5(8.5)11 μm, PN = 10(14)19, P∅B = 1(1.6)2 (8 specimens measured).

Remarks. We do accept that *Helios* Cramer (1964b) is a junior synonym of *Duvernaysphaera* Staplin (1961), as discussed by Cramer & Díez (1972), Playford (1977), Mullins (2001), among others. *Duvernaysphaera jelinii* Pöthe de Baldis (1974) is considered to be a junior synonym of *D. gothica* Martin (1968) by Pöthe de Baldis (1981). On the other hand, *D. gothica* is considered a junior synonym of *D. aranides* (Cramer) by Cramer & Díez (1972). This latter criterion is accepted in this work.

Genus ***Leiosphaeridia*** Eisenack emend. Downie & Sarjeant 1963

Type species: *Leiosphaeridia baltica* Eisenack 1958a.

Leiosphaeridia wenlockia Downie 1959

(Figs. 6.12, 7.2)

Dimensions. V∅ = 25(27.8)32 μm (13 specimens measured).

***Leiosphaeridia* sp. A**

(Figs. 6.14, 7.7)

Description. Vesicle spherical, thin walled (0.5 μm), scabrated to slightly punctuated. Foldings are not distinct. Vesicle diameter varies from.

Dimensions. V∅ = 38(44.9)55 μm (9 specimens measured).

Remarks. *Leiosphaeridia tenuissima* Eisenack (1958b) differs only in size from the specimens described here, being the former much bigger; *L. wenlockia* Downie (1959) differs from *L.* sp. A in its size and the characteristics of its wall, being thicker and with foldings in the latter.

Anteturma SPORITES Potonié 1893
Turma TRILETES Reinsch 1881
Subturma ZONOTRILETES Waltz 1935 in Luber & Waltz 1938
Infraturma CRASSITI Bharadwaj & Venkatachala 1961

Genus ***Ambitisporites*** Hoffmeister 1959

Type species: *Ambitisporites avitus* Hoffmeister 1959.

Ambitisporites avitus Hoffmeister 1959

(Fig. 6.13)

Dimensions. ∅ = 36(39.7)45 μm, Cw = 3(3.3)4 μm (9 specimens measured).

Spore Type A

(Fig. 7.11)

Description. Miospore trilete, radial, zonate with subcircular amb. Laesura distinct, simple, with straight sides and extending to the zone borders. Exine laevigated.

Dimensions. ∅ = 65 μm, Zw = 15 μm (1 specimen measured).

ALGAE *INCERTAE SEDIS*

Genus ***Proteolobus*** Wood 1997

Type species: *Proteolobus walli* Wood 1997.

Proteolobus cylindrus Al-Ruwaili 2000

(Fig. 7.8)

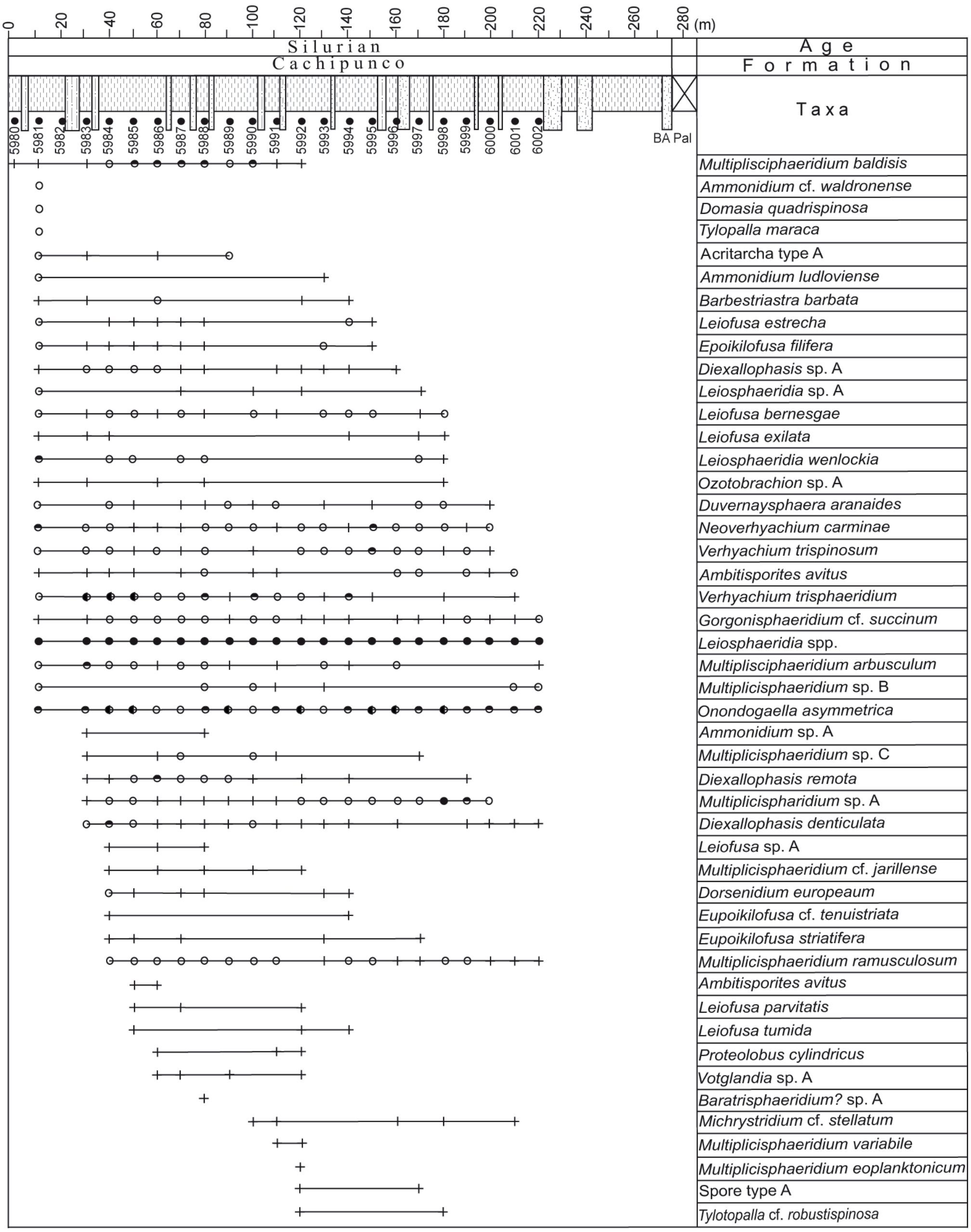
Dimensions. PL = 35-40 μm, T = 75-80 μm, PØ = 10 μm (1 specimen measured).

MICROPLANKTON CHARACTERISTICS

Angosto de Los Pereyras Section (Fig. 8)

The analized associations present a great diversity of species between the 10 and 140 meters, being identified more than 22 species in each level. On the other hand, in the base and the superior section of the stratigraphic column the specific diversity is much lower (between 8-17 species per level)

At a generic level, associations are clearly dominated by the Leiospaeridia genera, with minor participation of *Onondogaella*, *Multiplicisphaeridium*, *Diexallophasis*, *Verhyachium*, *Neovarhyachium,* and *Leiofusa*.



Figs. 8. Percentage distributions of the taxas identified at Angosto los Pereyras (Fig. 3) and Cumbre Los Pereyras (Fig. 4) according to the following + Less than 1% ○ Between 1-5% ◒ Between 5-10% ◑ Between 10-20% ● More than 20%

In according to this, at specific level, a conspicuous predominance of *Onondogaella asymmetrica, Gorgonisphaeridium succinum, Multiplicispheridium arbusculum, M. ramusculosum, Diexallophasis denticulata, Verhyachium trisphaeridium, Ambitisporites avitus, Neoveryhachium carminae, Duvernaysphaera aranaides,* and *Leiofusa bernesgae*, among others could be observed.

A Wenlockian-Ludlovian age is inferred for this association based on the stratigraphic range of the most important species identified for it (Fig. 5).

The age for this section, as stated by Grahn & Gutiérrez (2001) based on the chitinzoarian content, is slightly younger (Wenlokiano-Pridoliano)

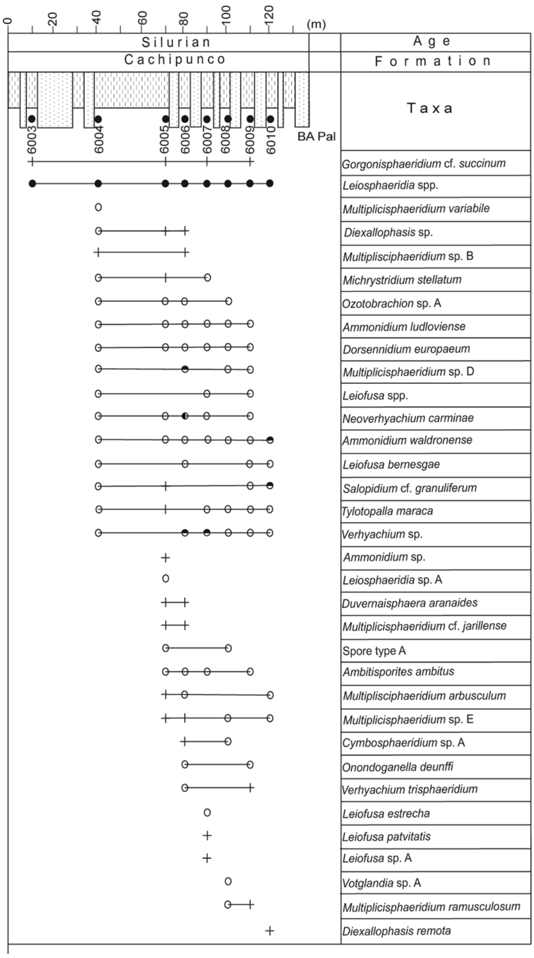


Fig. 9. Same reference as in Fig. 8.

than the age obteneid from the acritarchs (Ludlovoian-Wenlockian).

Cumbre de Los Pereyras Section (Fig. 9)

The inferior sector of this section (30 meters) comprises only one palynological association (BA Pal 6003). In that section only *Leiosphaeridia* and some specimens of *Gorgonispaeridium* where identified. Between the 40 and 120 meters, the studied associations (7 in total) display a moderate to low diversity (between 3-20 species per level).

In concordance with Angosto Los Pereyras, in the asssociations recovered for Cumbre Los Pereyras, preveil the genus *Leiosphaeridia*. Notwithstanding, this genus coexist mainly with specimens of the genera *Verhyachium, Ammonidium, Dorsenidium, Multiplicisphaeridium*, *Tylotopalla,* and *Leiofusa*.

The more prominent species for this section are: *Gorgonisphaeridium succinum, Tylotopalla maraca*, *Ammonidium ludloviense, A. waldronense, Dorsennidium europaeum, Neoveryhachium carminae, Leifusa bernesgae*, *Salopidium* sp. cf. *S. granuliferum* y *Multiplicispheridium arbusculum,* among others.

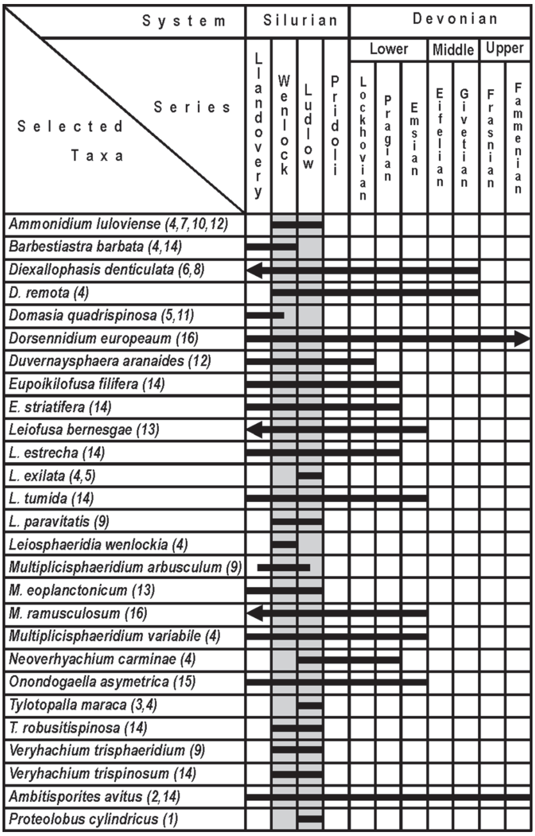


Fig. 10. Stratigraphical ranges of the more conspicuous species identified in Angosto Los Pereyras and Cumbre Los Pereyras associations. References. 1, Al-Ruwallii, 2000; 2, Cramer, 1968; 3, Díez & Cramer, 1976; 4, Fensome *et al.*, 1990; 5, Hill, 1974; 6, Hill & Molyneux, 1988; 7, Lakova & Göncüoğlu, 2005; 8, Molyneux *et al.*, 1996; 9, Mullins, 2001; 10, Mullins, 2002; 11, Playford, 2003; 12, Rubinstein, 1992b; 13, Rubinstein, 1993; 14, Rubinstein, 1995; 15, Rubinstein & Toro, 2006; 16, Wicander & Playford, 1985.

Comparing these findings with those obtained for Angosto Los Pereyras, and the stratigraphic ranges of the species identified (Fig. 10), we are able to constrain the age of this section to a Welnckian-Ludlovian period.

Taking into account the previous distribution in other Argentinian formations of the identified taxones from Cachipunco Formation (Fig. 11) it is possible to notice a remarkable afinity with the palynoflore from Los Espejos Formation.

TAXA	Los Espejos	La Chilca	Don Barulio	Copo	La Horqueta	Lipeón	Salar del Rincón	Cachipunco
	FORMATION							
Leiofusa bernesgae	X	X	X	X				X
Duvernaysphaera aranaides	X	X		X				X
Eupoikilofusa striatifera	X	X		X		X		X
Ammonidum ludloviense	X	X	X		X			X
Diexallophasis remota	X	X					X	X
Dorsennidium europeaum	X	X						X
Leiofusa estrecha	X	X			X			X
Leiofusa tumida	X	X	X				X	X
Micrhystridium stellatum	X	X						cf.
Multiplicisphaeridium ramusculosum	X	X						X
Salopidium granuliferum	X	X						cf.
Tylotopalla robustispinosa	X	X						cf.
Veryhachium trisphaeridium	X	X	X					X
Veryhachium trispinosum	X	X						X
Barbestriastra barbata	X			X				X
Diexallophasis denticulata	X		X	X				X
Eupoikilofusa filifera	X		X	X	X			X
Multiplicisphaeridium variabile	X			X				X
Ambitisporites avitus	X							X
Eupoikilofusa tenuistriata	X							cf.
Leiosphaeridia wenlockia	X							X
Multiplicisphaeridium eoplanctonicum	X							X
Neoveryhachium carminae	X							X
Onondogaella asymmetrica	X					X		X
Diexallophasis sp. A	X							X
Ammonidium waldronense		X						cf.
Multiplicisphaeridium jarillense		X						cf.
Multiplicisphaeridium arbusculum							X	X
Leiofusa sp. A	X		X					X
Multiplicisphaeridium baldisii	X			X				X
Domasia quadrispinosa								X
Tylotopalla maraca								X
Leiofusa exilata								X
Leiofusa parvitatis								X
Proteolobus cylindricus								X

Fig. 11. Comparation of the taxas identified for Cachipunco Fm. with those found in other Argentinean formations. References: Los Espejos Fm. (Pöthe de Baldis, 1975a, 1975b, 1981, 1998; Rubinstein, 1990, 1991, 1992a, 1992b, 1993, 2000; Rubinstein & Brussa 1999), La Chilca Fm. (Pöthe de Baldis, 1987, 1997b, 1998; Rubinstein & Brussa, 1999), Don Braulio Fm. (Pöthe de Baldis; 1997a), Copo Fm. (Pöthe de Baldis, 1971, 1974), La Horqueta Fm. (Rubinstein, 1997), Lipeón Fm. (Rubinstein, 2005; Rubinstein & Toro, 2006), Salar del Rincón Fm. (Rubinstein & Vaccari, 2004).

Though the palynological association from that litostratigraphic unit is one of the better known of Argentina (see Rubinstein, 1993, 1995), is important to mention the fact that 27 species over a total of 36, have been identified for both formations.

There are described for the first time for the Argentinian Silurian: *Domasia quadrispinosa, Gorgonisphaeridium succinum, Leiofusa exilata, L. parvitatis, Proteolobus cylindricus,* and *Tylotopalala maraca.*

CONCLUSIONS

The palynological content of Cachipunco Formation is described here for the first time. The following species: *Domasia quadrispinosa, Leiofusa exilata, L. parvitatis, Proteolobus cylindricus* y *Tylotopalala maraca,* are described for the first time for the Silurian of Argentina. A new species, *Multipliscispharidium baldisii*, is here proposed.

Finally, based on the palynological content of the Cachipunco Formation, a Wenlock-Ludlow age is assigned to this litostratigraphic unit. Such age, slightly differs from the one obteined by Grahn & Gutiérrez (Wenlock-Pridoli, 2001), from the chitinozoarian content of this formation.

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