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New palynological data from the Malanzán Formation (Carboniferous), La Rioja Province, Argentina

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Abstract. Palynological analysis of the Malanzán Formation in the Paganzo Basin, northwestern Argentina, has yielded six well-preserved palynological assemblages. Fifty-nine species were determined: 37 spores, 19 pollen grains, and 3 algae. Thirty-two of these species have not been recorded so far from the Malanzán Formation, and all pollen species are illustrated for the first time. These assemblages are referred to Sub-Biozone A of the *Raistrickia densa-Convolutispora muriornata* Biozone, Serpukhovian in age. Moreover, the abundance of monosaccate pollen grains might constrain the Malanzán Formation to the late Serpukhovian.

Resumen. Nuevos datos palinológicos de la Formación Malanzán (Carbonífero), provincia de La Rioja, Argentina. Nuevas asociaciones palinológicas han sido obtenidas de la Formación Malanzán (Cuenca Paganzo), noroeste de Argentina. En las seis muestras fértiles estudiadas para este trabajo, se identificaron un total de cincuenta y nueve especies de palinomorfos: 37 especies de esporas, 19 de granos de polen y 3 especies de algas. Treinta y dos de las especies de palinomorfos reconocidas no habían sido reportadas hasta el momento para la unidad. Además, se ilustran por primera vez los granos de polen de la Formación Malanzán. Las asociaciones estudiadas son referidas a la Biozona *Raistrickia densa-Convolutispora muriornata*, y más precisamente a la sub Sub-Biozona A, de edad serpukhoviana. Además, la abundancia de granos de polen monosacados podría restringir a la Formación Malanzán al Serpukhoviano tardío.

Key words. Argentina. Malanzán Formation. Carboniferous. Palynology.

Palabras clave. Argentina. Formación Malanzán. Carbonífero. Palinología.

Introduction

Thick Upper Palaeozoic sequences located in western and northwestern Argentina and constituting the Río Blanco, Calingasta-Uspallata and Paganzo basins, represent one of the most continuous sedimentary sequences of this age in Gondwana. During the past two decades, a large number of systematic-palynological and biostratigraphic studies of these Carboniferous and Permian sediments have been published (e.g., Archangelsky *et al.*, 1996; Césari and Limarino, 2002; Césari and Gutiérrez, 2001; Gutiérrez *et al.*, 2003; Gutiérrez and Barreda, 2006). Despite this extensive research on the Late Palaeozoic, some issues are still unresolved, including the lack of a detailed characterization of the latest Mississippian palynological content. Such study would allow a clear distinction between Mississippian and Pennsylvanian palynofloras; i.e., those preserved in glaciogene sedimentary sequences deposited during the "Middle Carboniferous glaciation" event of the latest Mississippian-earliest Pennsylvanian, thus providing an important tool for stratigraphic correlations. In this work, new palynological assemblages recovered from fine-grained sediments of the Malanzán Formation, deposited in a fjord environment (during a postglacial transgressive event) and in a deltaic environment, are described in detail. The assemblages contain abundant monosaccate and bisaccate pollen grains, which are identified and illustrated for the first time from this formation.

Geological setting

Located in the northwestern region of Argentina, the Paganzo Basin includes sequences referred to the Paganzo Group by Azcuy and Morelli (1970) and dated as Serpukhovian-Permian. In the Sierra de los Llanos area (figure 1), this group is represented, in ascending order, by the Malanzán, Loma Larga, Sol-

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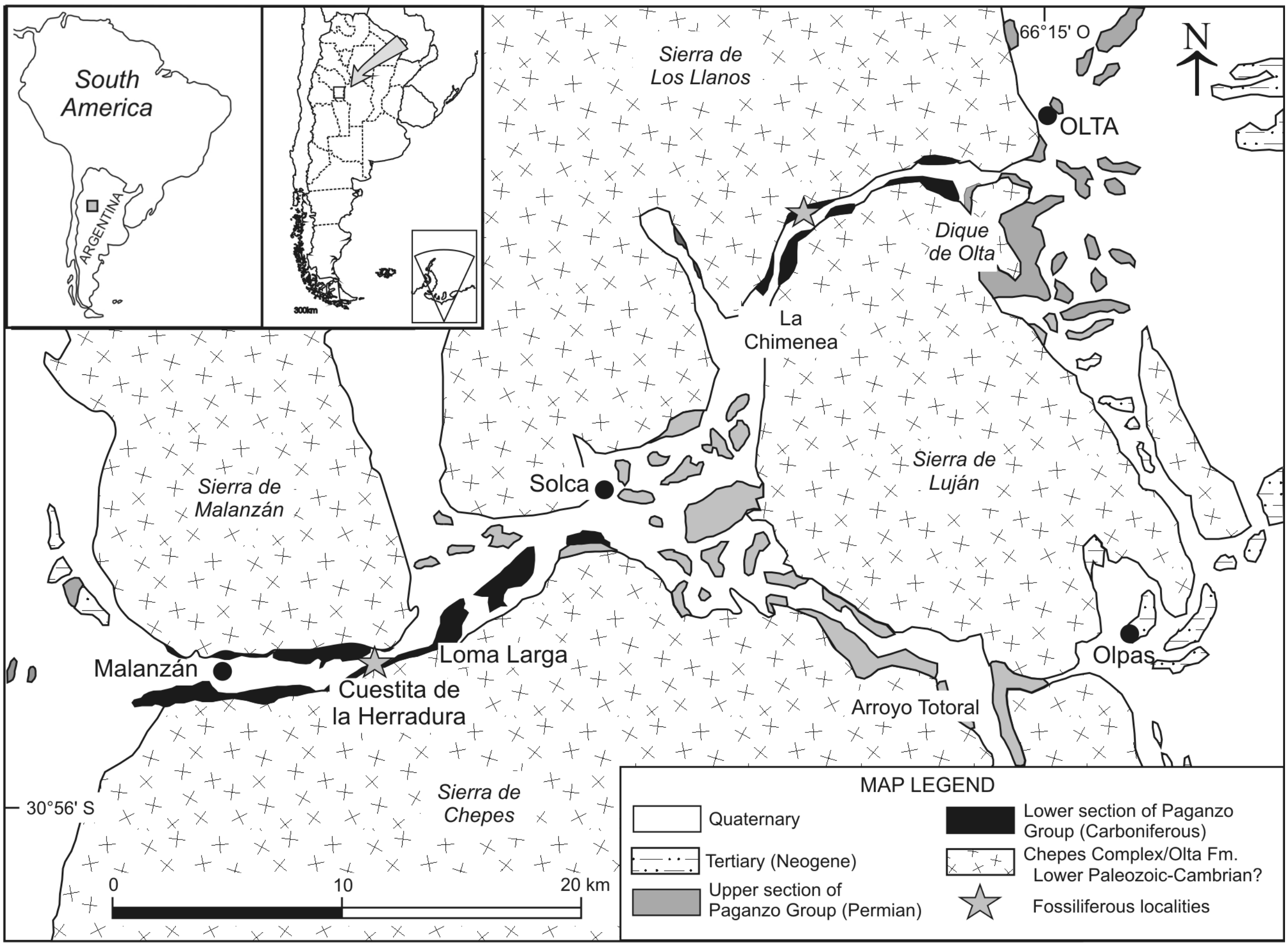


Figure 1. Geological map and geographic location of the fossiliferous localities (modified from Net , 1999) / *mapa geológico y ubicación geográfica de las localidades fosilíferas (modificado de Net, 1999).*

ca, and La Colina formations (Andreis *et al*, 1986; Net, 1998). The Malanzán Formation is overlain conformably by conglomerates, sandstones and some mudstone beds of the Loma Larga Formation, and lies on crystalline basement of the Cambrian Pacatala Complex (Page *et al*., 2002) and the Ordovician Chepes Complex (Pieters and Skinom, 1997).

The Malanzán Formation was originally defined by Furque (1968) to include Late Palaeozoic sequences outcropping in the Sierra de los Llanos (Bracaccini, 1946, 1948). Later, Azcuy (1975a) subdivided the Malanzán Formation into three members, named Divisoria, Estratos Carbonosos and Conglomerados Amarillo Verdosos-Violáceos (in ascending order). A different classification was proposed by Andreis *et al*. (1986), who restricted the name Malanzán Formation to the basal member (the "Divisoria Member" of Azcuy, 1975a). Moreover, Andreis *et al*. (1986) defined the Loma Larga Formation to incorporate Azcuy's (1975a) Estratos Carbonosos and Conglomerados Amarillo Verdosos-Violáceos members. More recently, Net (1998) and Net and Limarino (1999) included only the Estratos Carbonosos Member in the Loma Larga Formation, the upper member being considered part of the overlying Solca Formation, defined by Andreis *et al*. (1986).

In the studied area, the Malanzán Formation, up to 345 m thick, is segregated into five sections based on lithology, sedimentary structures, and cyclicity (figure 2). (1) The lowermost section, 85 m thick, is composed of coarse-grained conglomerates, breccias, massive or cross-stratified pebble sandstones, diamictites and some shales with dropstones. These deposits were interpreted by Andreis *et al*. (1986) as formed in alluvial fans. (2) Grey laminated mudstones with dropstones (55 m thick) bearing megaclasts up to 20 cm in diameter. Some beds of massive diamictites, up to 1 m thick, and beds of ripple cross-laminated sandstones are intercalated within the laminated mudstones. These deposits were interpreted by Limarino and Césari (1988) and Sterren and Martínez (1996) as having accumulated in glaciolacustrine environments; however, Limarino *et al*. (2002) suggested that the sediments represent the be-

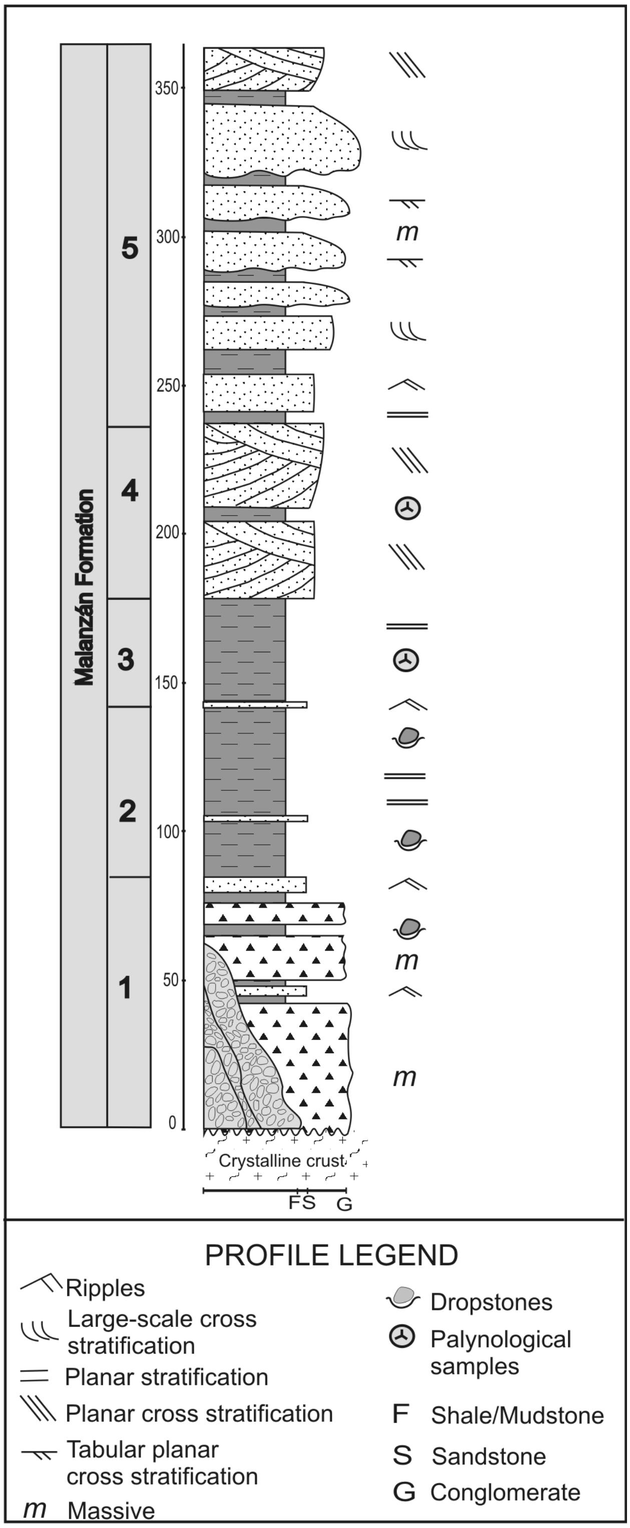


Figure 2. Schematic stratigraphic section of the Malanzán Formation, showing the provenance of palynological samples (modified from Net, 1999) / *sección estratigráfica esquemática de la Formación Malanzán, mostrando la ubicación de las muestras palinológicas (modificado de Net, 1999).*

ginning of the postglacial "Middle Carboniferous" transgression in the Paganzo Basin. (3) Black shales and mudstones without dropstones, up to 35 m thick, including thin beds of marls and ripple cross-laminated fine-grained sandstones. This interval is believed to have been deposited during the maximum post-glacial flooding event (Limarino *et al.*, 1996). From palynological data, Gutiérrez and Limarino (2001) suggested brackish conditions, with sedimentation in palaeofjords, as previously inferred by Net and Limarino (1999). New palynological samples from this section are documented herein. (4) Large-scale cross-bedded sandstones reaching 50 m in thickness, exhibiting megasets (up to 9 m thick) formed by the progradation of Gilbert-type deltas (Sterren and Martínez, 1996). Three palynological samples were collected from this interval. (5) Interbedded organic-rich mudstones and ripple cross-laminated fine-grained sandstones (130 m thick) interpreted as mouth bar deposits.

Material and methods

The studied samples were obtained from the Malanzán Formation (Paganzo Basin) in La Rioja Province, Argentina (figures 1, 2). Three fossiliferous levels were sampled from outcrops of this formation at the La Chimenea locality in the Olta Valley; they consist of thin coal beds, interpreted as frontal bars of a delta, here designated as Section 4 (BA Pal 5811-13). Other three samples came from the Cuestita de la Herradura locality in the Malanzán valley, they consist of laminated mudstones without dropstones and are included in Section 3 (BA Pal 5814-16). All specimens illustrated herein (figures 3-6) are deposited in the palynological collection of the Museo Argentino de Ciencias Naturales "Bernardino Rivadavia" (BA Pal) and are slide-located by England Finder coordinates.

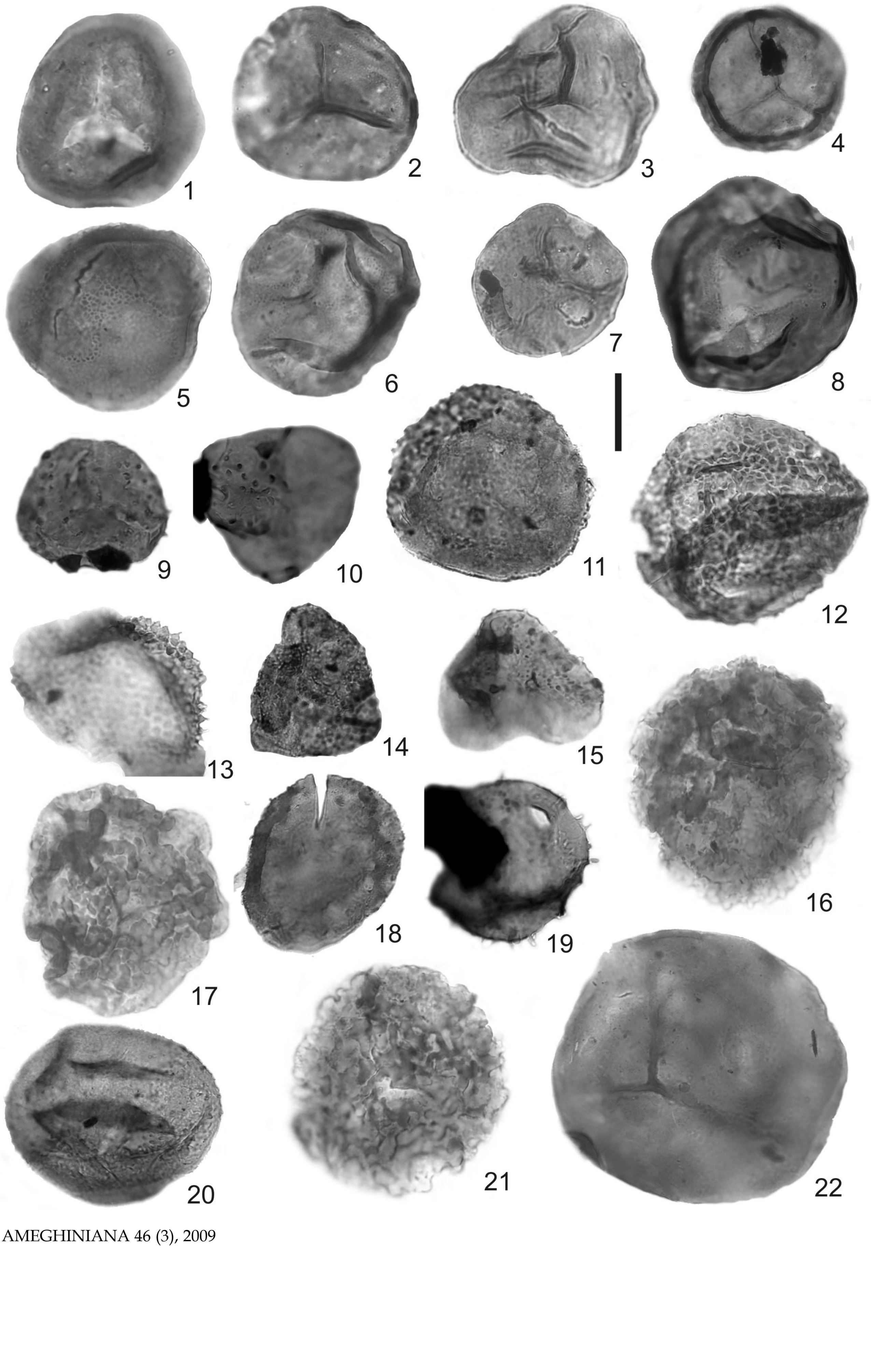
The samples were processed using standard palynological techniques for extraction and concentration of palynomorphs. The organic residues were sieved using 20 µm mesh and later mounted in glycerine jelly on microscope slides.

Systematic palynology

The identified palynomorphs (spores, pollen grains and algae) are listed below in alphabetical order (* indicates first report from the Malanzán Formation). Only the species recognized for the first time in Argentina, and those with doubtful specific assignment, are described.

Spores

Anapiculatisporites sp. cf. *A. concinnus* Playford 1962 (figure 3.10)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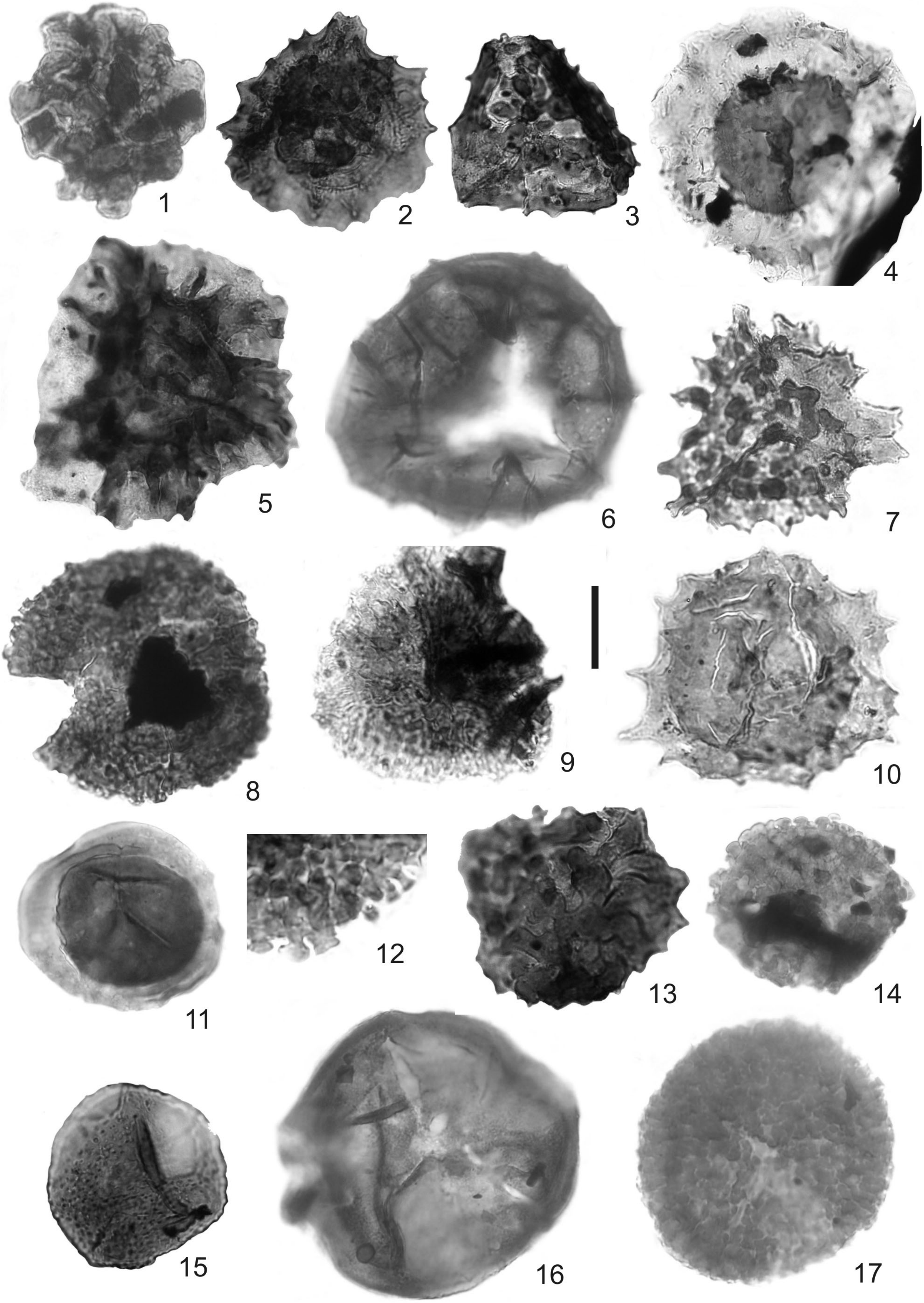
Apiculatasporites caperatus Menéndez and Azcuy 1969 (figure 3.20)
Apiculatisporis variornatus di Pasquo *et al*. 2003* (figure 3.19)
Apiculiretusispora alonsoi Ottone 1989* (figure 3.18)
Apiculiretusispora sp. cf. *A. ralla* (Menéndez and Azcuy) Menéndez and Azcuy 1971 (figure 3.9)
Convolutispora muriornata Menéndez 1965 (figure 3.21)
Cristatisporites inconstans Archangelsky and Gamerro 1979* (figure 4.7)
Cristatisporites menendezii (Menéndez and Azcuy) Playford 1978 (figure 4.13)
Cristatisporites rollerii Ottone 1989* (figure 4.2)
Cristatisporites stellatus (Azcuy) Gutiérrez and Limarino 2001 (figure 4.3)
Cristatisporites sp.* (figure 4.5)
Cyclogranisporites firmus Jones and Truswell 1992* (figure 3.5)
Cyclogranisporites plicatus Perez Loinaze and Césari 2004* (figure 3.6)
Cyclogranisporites rinconadensis Césari and Limarino 2002* (figure 3.11)
Dibolisporites disfacies Jones and Truswell 1992* (figure 3.13)
Dictyotriletes cortaderensis Césari and Limarino 1987 (figure 3.17)
Endosporites sp. * (figure 4.11)
Grandispora sp.* (figure 4.10)
Granulatisporites sp. cf. *G. austroamericanus* Archangelsky and Gamerro 1979* (figure 3.14)
Grossusporites microgranulatus (Menéndez and Azcuy) Perez Loinaze and Césari 2004* (figure 4.16)
Indotriradites volkheimeri (Azcuy) Perez Loinaze 2008 (figure 4.9)
Leiotriletes tiwarii (Saxena) Saxena 1993 (=*Leiotriletes virkii*)* (figure 3.3)
Lophotriletes intermedius Azcuy 1975a (figure 3.15)
Microreticulatisporites punctatus Knox 1950* (figure 4.15)
Punctatisporites gretensis Balme and Hennelly 1956* (figure 3.22)
Punctatisporites irrasus Hacquebard 1957* (figure 3.1)
Punctatisporites priscus Bharadwaj and Salujha 1965* (figure 3.2)
Punctatisporites sp. cf. *P. glaber* (Naumova) Playford 1962 (figure 3.8)
Raistrickia paganciana Azcuy 1975a (figure 4.1)
Raistrickia rotunda Azcuy 1975a (figure 4.14)
Raistrickia sp. cf. *R. radiosa* Playford and Helby 1968* (figure 4.8, 12, 17)
Reticulatisporites asperidictyus Playford and Helby 1968 (figure 3.16)
Reticulatisporites magnidictyus Playford and Helby 1968* (figure 4.6)
Retusotriletes sp. 1* (figure 3.7)
Retusotriletes sp. 2* (figure 3.4)
Vallatisporites ciliaris (Luber) Sullivan 1964 (figure 4.4)
Verrucosisporites andersonii Backhouse 1988* (figure 3.12)

Pollen grains

Caheniasaccites densus Lele and Karin *emend*. Gutiérrez 1993* (figure 5.12)
Cannanoropollis densus (Lele) Bose and Maheshwari 1968 (figure 5.8)
Cannanoropollis janakii Potonié and Sah 1960 (figure 5.3)
Cannanoropollis mehtae (Lele) Bose and Maheshwari 1968 (figure 6.4)
Circumplicatipollis plicatus Ottone and Azcuy 1988 (figure 5.14)
Colpisaccites granulosus Archangelsky and Gamerro 1979* (figure 5.15)
Costatascyclus crenatus Felix and Burbridge *emend*. Urban 1971* (figure 5.13)
Crucisaccites monoletus Maithy 1965 (figure 5.10)
Divarisaccus stringoplicatus Ottone 1991* (figure 5.6)
Limitisporites rectus Leschik 1956* (figure 5.2)
Peppersites sp. cf. *P. ellipticus* Ravn 1979* (figure 5.1, 4)
Plicatipollenites gondwanensis (Balme and Hennelly) Lele 1964* (figure 5.16)
Plicatipollenites trigonalis Lele 1964* (figure 6.5)
Plicatipollenites malabarensis (Potonié and Sah) Foster 1975 (figure 5.11)

Figure 3. 1, ***Punctatisporites irrasus*** Hacquebard 1957 BA Pal 5811-1 : Y49/3; **2,** ***Punctatisporites priscus*** Bharadwaj and Salujha 1965 BA Pal 5813-1 : X48/3; **3,** ***Leiotriletes tiwarii*** (Saxena) Saxena 1993 1965 BA Pal 5811-2 : E50/4; **4,** ***Retusotriletes*** sp. 2 BA Pal 5811-4 :P28/1; **5,** ***Cyclogranisporites firmus*** Jones and Truswell 1992 BA Pal 5812-1 : B12/3; **6,** ***Cyclogranisporites plicatus*** Perez Loinaze and Césari 2004 BA Pal 5813-2 : H45/4; **7,** ***Retusotriletes*** sp. 1 BA Pal 5811-4 : P28/2; **8,** ***Punctatisporites*** sp. cf. ***P. glaber*** (Naumova) Playford 1962 BA Pal 5812-3 : W40/1; **9,** ***Apiculiretusispora*** sp. cf. ***A. ralla*** (Menéndez and Azcuy) Menéndez and Azcuy 1971 BA Pal 5816-2 : G32/3; **10,** ***Anapiculatisporites*** sp. cf. ***A. concinnus*** Playford 1962 BA Pal 5816-2 : E45/3; **11,** ***Cyclogranisporites rinconadensis*** Césari and Limarino 2002 BA Pal 5811-4 : R40/2; **12,** ***Verrucosisporites andersonii*** Backhouse 1988 BA Pal 5812-1 : M26/3; **13,** ***Dibolisporites disfacies*** Jones and Truswell 1992 BA Pal 5813-1 : D23/2; **14,** ***Granulatisporites*** sp. cf. ***G. austroamericanus*** Archangelsky and Gamerro 1979 BA Pal 5811-1 : K51/4; **15,** ***Lophotriletes intermedius*** Azcuy 1975 BA Pal 5816-1 : V38/3; **16,** ***Reticulatisporites asperidictyus*** Playford and Helby 1968 BA Pal 5812-1 : D51/3; **17,** ***Dictyotriletes cortaderensis*** Césari and Limarino 1987 BA Pal 5811-1 : N53/1; **18,** ***Apiculiretusispora alonsoi*** Ottone 1989 BA Pal 5813-1 : S33/3; **19,** ***Apiculatisporis variornatus*** di Pasquo *et al*. 2003 BA Pal 5815-3 : Z30/3; **20,** ***Apiculatasporites caperatus*** Menéndez and Azcuy 1969 BA Pal 5813-2 : Q30/3; **21,** ***Convolutispora muriornata*** Menéndez 1965 BA Pal 5814- : J22/4; **22,** ***Punctatisporites gretensis*** Balme and Hennelly 1956 BA Pal 5813-2 : Z55/3. Scale bar / *escala gráfica*: 20 µm.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Potonieisporites barrelis Tiwari 1965* (figure 6.1)
Potonieisporites densus Maheshwari 1967* (figure 5.5)
Potonieisporites magnus Lele and Karim 1971 (figure 6.2)
Potonieisporites neglectus Potonié and Lele 1961* (figure 5.9)
Potonieisporites sp. cf. *P. jayantiensis* Lele and Karim 1971* (figure 5.7)

Algae

Tetraporina punctata (Tiwari and Navale) Kar and Bose 1976 (figure 6.3)
Botryococcus sp. (figure 6.6)
Navifusa sp. (figure 6.7)

Anteturma PROXIMEGERMINANTES Potonié 1970
Turma TRILETES Reinsch *emend*. Dettmann 1963
Suprasubturma ACAVATITRILETES Dettmann 1963
Subturma AZONOTRILETES Luber *emend*. Dettmann 1963
Infraturma LAEVIGATI Bennie and Kidston *emend*. Potonié 1956
Infraturma RETUSOTRILETI Streel 1964

Genus ***Retusotriletes*** Naumova *emend*. Streel 1964

Type species. *Retusotriletes simplex* Naumova 1953.

Retusotriletes sp. 1
Figure 3.7

Description. Spore radial, trilete. Amb subcircular. Laesurae straight, with raised narrow lips, length three-quarters of spore radius, with imperfect curvaturae. Exine laevigate, about 0.8 µm thick.
Dimensions. Equatorial diameter: 40 µm (1 specimen).
Comparisons. *Retusotriletes anfractus* Menéndez and Azcuy 1969 differs by its sinuous laesurae. *Retusotriletes tenuis* Menéndez 1965 has granular exine. *Retusotriletes simplex* Naumova 1953 is smaller (equatorial diameter, 30-35 µm). *Retusotriletes indignus* Azcuy 1975a differs by its thicker exine.

Retusotriletes sp. 2
Figure 3.4

Description. Spore radial, trilete. Amb circular. Laesurae straight, with raised narrow lips, length three-quarters of spore radius, with perfect curvaturae. Exine laevigate, about 0.8 µm thick.
Dimensions. Equatorial diameter: 42 µm (1 specimen).
Comparisons. *Retusotriletes minutus* Butterworth and Mahdi 1982 differs by its thicker exine. *Retusotriletes* sp. 1 possesses imperfect curvaturae.

Infraturma APICULATI Bennie and Kidston *emend*. Potonié 1956
Subinfraturma GRANULATI Dybová and Jachowicz 1957

Genus ***Anapiculatisporites*** Potonié and Kremp 1954

Type species. *Anapiculatisporites isselburgensis* Potonié and Kremp 1954.

Anapiculatisporites sp. cf. ***A. concinnus*** Playford 1962
Figure 3.10

Remarks. Following such authors as Dueñas and Césari (2005), it is preferred to retain this species in the genus *Anapiculatisporites*, rejecting Ravn's (1991) proposal. *Anapiculatisporites argentinensis* Azcuy 1975a can be considered conspecific with *A. concinnus*, as suggested by such authors as Jones and Truswell (1992) and Stephenson (2004).

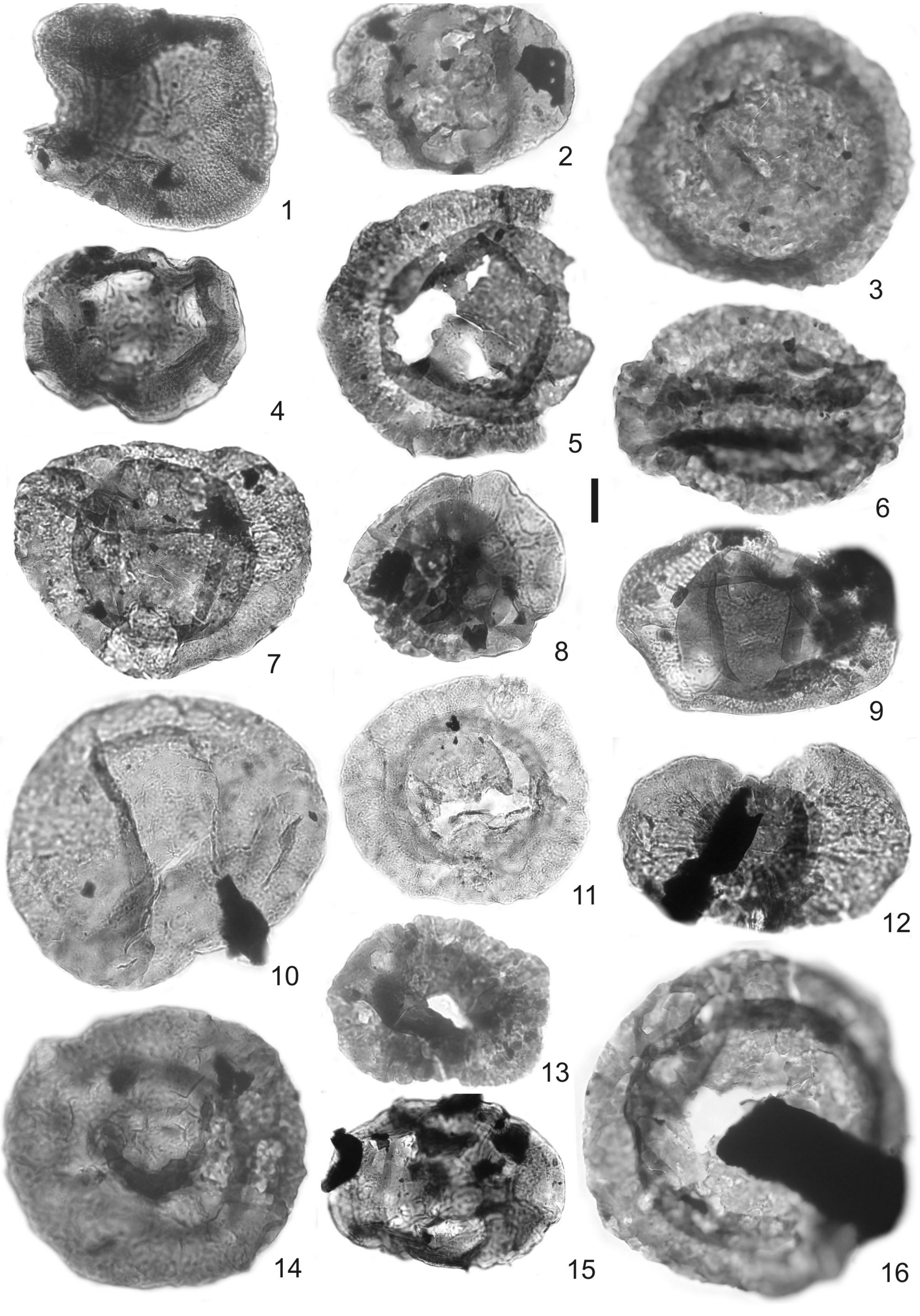
Genus ***Lophotriletes*** Naumova *emend*. Potonié and Kremp 1954

Type species. *Lophotriletes gibbosus* (Ibrahim) Potonié and Kremp 1954.

Lophotriletes intermedius Azcuy 1975a
Figure 3.15

Remarks. The exine of the studied specimens is slightly thinner than was reported for this species by Azcuy (1975a).

Figure 4. 1, ***Raistrickia paganciana*** Azcuy 1975 BA Pal 5814-3: W53/3; **2,** ***Cristatisporites rollerii*** Ottone 1989 BA Pal 5812-1: P35/2; **3,** ***Cristatisporites stellatus*** (Azcuy) Gutiérrez and Limarino 2001 BA Pal 5812-1: L27/2; **4,** ***Vallatisporites ciliaris*** (Luber) Sullivan 1964 BA Pal 5816-2: W34/1; **5,** ***Cristatisporites*** sp. BA Pal 5812-2: Z52/4; **6,** ***Reticulatisporites magnidictyus*** Playford and Helby 1968 BA Pal 5812-2: Q27/2; **7,** ***Cristatisporites inconstans*** Archangelsky and Gamerro 1979 BA Pal 5811-2: T39/4; **8, 12, 17,** ***Raistrickia*** sp. cf. ***R. radiosa*** Playford and Helby 1968; **8,** BA Pal 5812-1: A28/2; **12,** BA Pal 5816-5: K40/4, sculptural detail/ *detalle de la escultura*; **17,** BA Pal 5811-5: A28/3; **9,** ***Indotriradites volkheimerii*** Azcuy 1975 BA Pal 5814-2: X29/3; **10,** ***Grandispora*** sp. BA Pal 5812-1: J23/4; **11,** ***Endosporites*** sp. BA Pal 5812-3: O38/2; **13,** ***Cristatisporites menendezii*** (Menéndez and Azcuy) Playford 1978 BA Pal 5811-2: O53/3; **14,** ***Raistrickia rotunda*** Azcuy 1975 BA Pal 5815-3: H48/4; **15,** ***Microreticulatisporites punctatus*** Knox 1950 BA Pal 5816-3: Y28/2; **16,** ***Grossusporites microgranulatus*** (Menéndez and Azcuy) Perez Loinaze and Césari 2004 BA Pal 5816-3: G32/4. Scale bar: 20 µm except 12: 10 µm / *escala gráfica: 20 µm con excepción de 12: 10 µm.*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Genus ***Apiculiretusispora*** Streel 1964

Type species. *Apiculiretusispora brandtii* Streel 1964.

Apiculiretusispora sp. cf. ***A. ralla*** (Menéndez and Azcuy) Menéndez and Azcuy 1971
Figure 3.9

Description. Spore radial, trilete. Amb subcircular. Laesurae straight, simple, extending almost to equator, ending in imperfect curvaturae. Proximal face laevigate. Distal face sculptured irregularly and sparsely with grana and coni (0.5-1.5 µm in basal width and height). Exine 1.5 µm thick.
Dimensions. Equatorial diameter: 42 µm (1 specimen).
Comparisons. Since only one poorly preserved specimen was found, the specific assignment is made reservedly.
Distribution. This species was previously recorded in Pennsylvanian sequences of Argentina and Brazil (e.g., Ottone, 1989, 1991; García, 1995; Longhim *et al.*, 2002; di Pasquo, 2003; di Pasquo *et al.*, 2003).

Infraturma BACULATI Dybová and Jachowicz 1957

Genus ***Raistrickia*** Schopf, Wilson and Bentall *emend.* Potonié and Kremp 1954

Type species. *Raistrickia grovensis* Schoff, Wilson and Bentall 1944.

Raistrickia sp. cf. ***R. radiosa*** Playford and Helby 1968
Figure 4.8, 12, 17

Description. Spores radial, trilete. Amb subcircular to circular. Laesurae straight, simple, length three-quarters of spore radius. Exine with densely distributed sculptural elements (1-2 µm in basal width, 1.5-3 µm high) having straight sides and blunt, rounded, or expanded apices, and occasionally fungiform elements. Exine 1.5-2 µm thick.
Dimensions. Equatorial diameter: 53(63)72 µm (17 specimens).
Comparisons. *Raistrickia radiosa* Playford and Helby 1968 differs from the studied specimens in having reduced sculptural elements on the proximal face.
Distribution. This species was recovered from palynoflora of Australia (Playford and Helby 1968) and Argentina (Gutiérrez and Césari, 1989; di Pasquo, 2003).

Genus ***Reticulatisporites*** Ibrahim *emend.* Potonié and Kremp 1954

Type species. *Reticulatisporites reticulatus* (Ibrahim) Ibrahim 1933.

Reticulatisporites magnidictyus Playford and Helby 1968
Figure 4.6

1991 *Reticulatisporites riverosii* Ottone, pp. 126-127, plate 1, figure 10, plate 2, figure 10.

Remarks. Examination of the original specimens used by Ottone (1991) for erecting *Reticulatisporites riverosii* indicates that they possess all the diagnostic characteristics of *Reticulatisporites magnidictyus*. Dino and Playford (2002a) noted that this species tends to have larger lumina in proximal face. The Argentinean spores have a considerable variation, with specimens showing similar size of lumina in both faces, and others having larger lumina in the proximal face. Accordingly, although Ottone did not recognize differences between proximal and distal in his specimens, *Reticulatisporites riverosii* is considered conspecific.

Reticulatisporites magnidictyus, originally described from the Australian Italia Road Formation by Playford and Helby (1968), is considered an important biostratigraphic marker, since its oldest records are late Visean. However, the species has been recorded in younger sediments (late Serpukhovian-Pennsylvanian) by Limarino and Gutiérrez (1990), Ottone (1991), Gutiérrez and Barreda (2006) and Perez Loinaze (2007).

Subturma ZONOTRILETES Waltz in Luber and Waltz 1938
Infraturma CINGULICAVATI Smith and Butterworth 1967

Figure 5. 1, 4, ***Peppersites*** sp. cf. ***P. ellipticus*** Ravn 1979; 1, BA Pal 5815-2: A42/2; **4,** BA Pal 5816-1: T22/2; **2,** ***Limitisporites rectus*** Leschik 1956 BA Pal 5816-2: Y56/1; **3,** ***Cannanoropolis janakii*** Potonié and Sah 1960 BA Pal 5815-1: P21/3; **5,** ***Potonieisporites densus*** Maheshwari 1967 BA Pal 5811-2: R45/4; **6,** ***Divarisaccus stringoplicatus*** Ottone 1991 BA Pal 5811-6: Z57/1; **7,** ***Potonieisporites*** sp. cf. ***P. jayantiensis*** Lele and Karim 1971 BA Pal 5811-4: Q48/0; **8,** ***Cannanoropolis densus*** (Lele) Bose and Maheshwari 1968 BA Pal 5816-2: Q49/3; **9,** ***Potonieisporites neglectus*** Potonié and Lele 1961 BA Pal 5815-1: J32/4; **10,** ***Crucisaccites monoletus*** Maithy 1965 BA Pal 5813-1: U21/2; **11,** ***Plicatisporites malabarensis*** (Potonié and Sah) Foster 1975 BA Pal 5813-2: Z25/3; **12,** ***Caheniasaccites densus*** Lele and Karin *emend.* Gutiérrez 1993 BA Pal 5813-2: N39/4; **13,** ***Costatascyclus crenatus*** Felix and Burbridge *emend.* Urban 1971 BA Pal 5813-1: Y18/4; **14,** ***Circumplicatipollis plicatus*** Ottone and Azcuy 1988 BA Pal 5811-5: U51/2; **15,** ***Colpisaccites granulosus*** Archangelsky and Gamerro 1979 BA Pal 5815-1: Y34/4; **16,** ***Plicatipollenites gondwanensis*** (Balme and Hennelly) Lele 1964 BA Pal 5811-2: D62/3. Scale bar / *escala gráfica: 20 µm.*

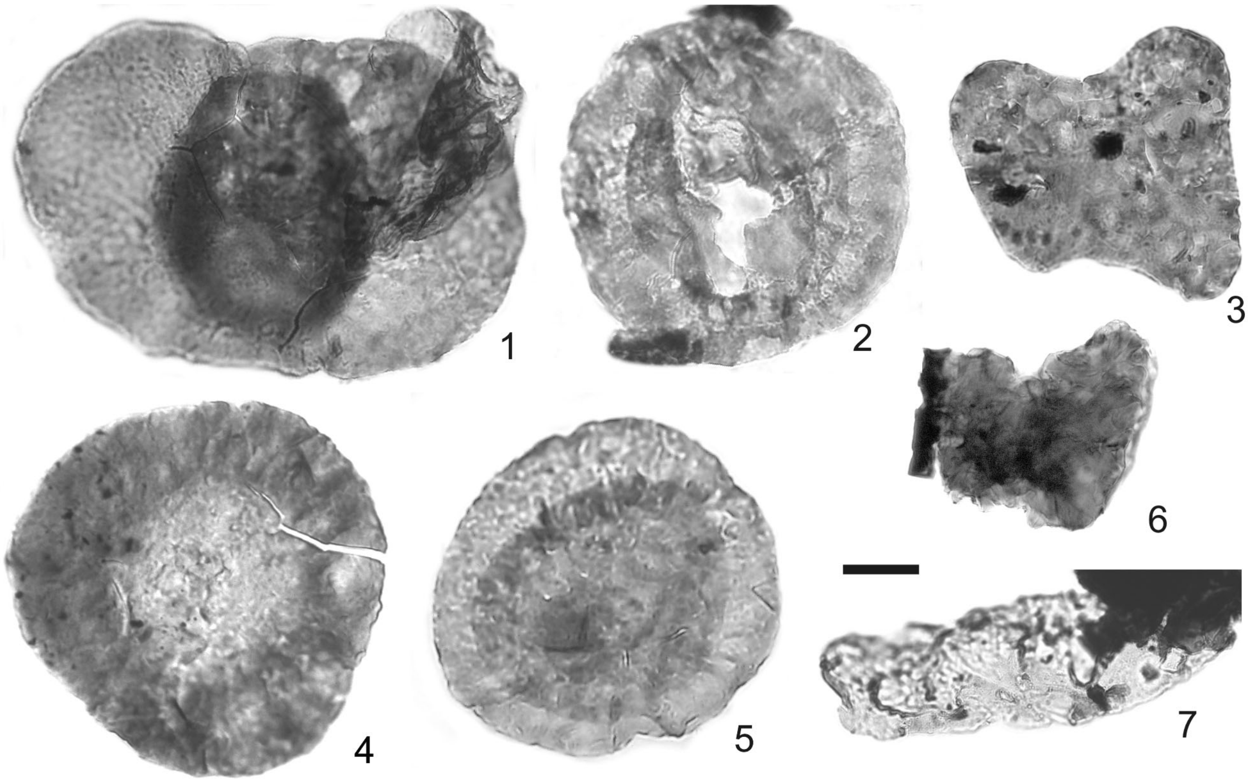

Figure 6. 1, ***Potonieisporites barrelis*** Tiwari 1965 BA Pal 5815-1: R24/4; **2,** ***Potonieisporites magnus*** Lele and Karim 1971 BA Pal 5816-1: X42/3; **3,** ***Tetraporina punctata*** (Tiwari and Navale) Kar and Bose 1976 BA Pal 5811-5: U60/1; **4,** ***Cannanoropolis mehtae*** (Lele) Bose and Maheshwari 1968 BA Pal 5813-1: C33/1; **5,** ***Plicatipollenites trigonali*****s** Lele 1964 BA Pal 5812-1: R57/4; **6,** ***Botryococcus*** sp. BA Pal 5815-1: M37/4; 7, ***Navifusa*** sp. BA Pal 5816-1: U54/3. Scale bar / *escala gráfica: 20 µm.*

Genus ***Cristatisporites*** Potonié and Kremp *emend.* Butterworth, Jansonius, Smith and Staplin 1964

Type species. *Cristatisporites indignabundus* (Loose) Potonié and Kremp 1954.

Cristatisporites sp.
Figure 4.5

Description. Spore radial, trilete, cavate, cingulizonate. Amb subtriangular. Inner body subtriangular. Laesurae straight, with narrow lips, extending almost to the equatorial margin. Proximal face laevigate. Central body with a narrow cingulum. Central area of the distal face sculptured with grana and sharp coni and spinae (3-10 µm high, 1.5-5 µm in basal width), frequently fused basally to form short cristae, often surmounted by a small spinus. Sculptural elements progressively diminished polewards. Translucent zona about 1/4 of spore radius, outer margin entire to slightly irregular, sculptured with sparsely distributed coni and spinae up to 5 µm high.
Dimensions. Equatorial diameter: 70 µm (1 specimen).

Comparisons. In *Cristatisporites indignabundus* (Loose) Staplin and Jansonius 1964, the margin of the central body bears setose spinae up to 2.5 µm high. *Cristatisporites lestai* Archangelsky and Gamerro 1979 and *C. longispinosus* Menéndez 1971 differ by having a markedly irregular zona. Moreover, in the former, the sculpture is dominantly verrucose. *Cristatisporites solaris* (Dias-Fabrício) Picarelli and Dias-Fabrício 1990 has a smaller diameter and dentate margin zona. In *Cristatisporites rollerii* Ottone 1989, the zonal width is approximately 1/2-1/3 of the spore radius, and the sculptural elements are differently distributed on the body.

Genus ***Indotriradites*** (Tiwari) Foster 1979

Type species. *Indotriradites korbaensis* Tiwari 1964.

Indotriradites volkheimeri (Azcuy) Perez Loinaze 2008
Figure 4.9

Dimensions. Equatorial diameter: 60, 68 µm (2 specimens).
Remarks. *Krauselisporites volkheimeri* Azcuy 1975b

was recently referred to *Indotriradites* by Perez Loinaze (2008) in accordance with the emendation of *Krauselisporites* by Scheuring (1974).

Suprasubturma PSEUDOSACCITITRILETES Richardson 1965
Infraturma MONOPSEUDOSACCITI Smith and Butterworth 1967

Genus ***Grandispora*** Hoffmeister, Staplin and Malloy *emend*. Neves and Owens 1966

Type species. *Grandispora spinosa* Hoffmeister, Staplin and Malloy 1955.

Grandispora sp.
Figure 4.10

Description. Spores radial, trilete, cavate. Amb triangular to rounded subtriangular. Laesurae straight, with narrow lips reaching almost to the equatorial margin. Intexine distinct, outline conformable with amb, about 2/3 of spore radius. Proximal surface laevigate. Distal surface sculptured with coni and grana, rounded in lateral view, and occasionally with irregularly distributed biform elements (2-6 µm high, 2-5 µm in basal width). Equatorial region with close-spaced coni and bacula (2-5 µm high and 5-10 µm in basal width).
Dimensions. Equatorial diameter: 56, 91 µm (2 specimens).
Comparison. The above specimens differ from previously described species of *Grandispora* in that the distal sculptural elements are smaller than those in the equatorial region. *Jayantisporites* Lele and Makada 1972 possesses a pseudozona, formed by basally fused sculptural elements. However, this genus differs from the Malanzán specimens in having basally fused, biform sculptural elements, thus forming cristate ridges on the distal face. *Grandispora uncata* (Hacquebard) Gupta 1969 is similar to these specimens, but both its proximal and distal faces are sculptured, and more densely so in the equatorial region. *Spinozonotriletes* sp. 1 Azcuy 1975b differs in having larger sculptural elements (8-23 µm).

Genus ***Endosporites*** Wilson and Coe *emend*. Bharadwaj 1965

Type species. *Endosporites ornatus* Wilson and Coe 1940 (designated by Schopf *et al*., 1944).

Endosporites sp.
Figure 4.11

Description. Spores radial, trilete, cavate, amb subcircular. Laesurae straight, simple, reaching almost to the equatorial margin. Intexine laevigate, outline conformable with amb. Exoexine microgranular, thicker than intexine.
Dimensions. Equatorial diameter: 42-51 µm, intexine diameter: 35-39 µm (6 specimens).
Comparisons. *Endosporites parvus* Menéndez 1965 possesses microgranular intexine and is smaller (equatorial diameter, 32 µm; intexine diameter, 15.5-18.5 µm). *Endosporites translucidus* Menéndez 1965 and *Endosporites* sp. of Gutiérrez and Limarino (2001) differ in having granular intexine. *Endosporites* sp. of Césari and Vázquez Nístico (1988) has laevigate and strongly folded exoexine. *Endosporites* sp. A of Azcuy (1975b) features a thicker exoexine and microgranular intexine. *Endosporites rhytidosaccus* Menéndez and Azcuy 1973 and *Endosporites minutus* Hoffmeister, Staplin and Malloy 1955 have microgranular and folded intexine.

Anteturma VARIEGERMINANTES Potonié 1970
Turma SACCITES Erdtman 1947
Subturma MONOSACCITES Chitaley *emend*. Potonié and Kremp 1954
Infraturma VESICULOMONORADITI Pant 1954

Genus ***Costatascyclus*** Felix and Burbridge *emend*. Urban 1971

Type species. Costatascyclus crenatus Felix and Burbridge *emend*. Urban 1971.

Costatascyclus crenatus Felix and Burbridge *emend*. Urban 1971
Figure 5.13

Description. Pollen grains bilateral, monosaccate. Amb transversely oval with crenulate margin. Corpus outline subcircular to oval in polar view, denser than saccus. Laesurae rarely perceptible. Saccus attached to corpus distally and proximally; finely endoreticulate, with coarse radial folds.
Dimensions. Overall breadth: 86(121)152 µm, overall length: 60(79)100 µm, corpus length: 48(62)72 µm, corpus breadth: 40(58)75 µm (32 specimens).
Comparisons. *Potonieisporites balmeii* (Hart) Segroves 1969 differ in having a pair of distinctive folds parallels the corpus margin.
Previous records. Pennsylvanian: Brazil, Paraná Basin, Itararé Subgroup (Souza, 2000; Souza *et al*., 2003); Parnaíba Basin, Piauí Formation (Dino and Playford, 2002b); Amazonas Basin, Tapajós Group (Playford and Dino, 2000); U.S.A. (Felix and Burbridge, 1967; Urban, 1971; Ravn, 1979, 1986). Lower Permian: Uruguay, San Gregorio Formation (Gutiérrez *et al*., 2006).

Subinfraturma DISACCITES Cookson 1947

Infraturma DISACCITRILETES Leschik 1956

Genus ***Colpisaccites*** Archangelsky and Gamerro 1979

Type species. *Colpisaccites granulatus* Archangelsky and Gamerro 1979.

Colpisaccites granulosus Archangelsky and Gamerro 1979
Figure 5.15

Comparisons. Compared to the material described originally by Archangelsky and Gamerro (1979), the present specimens are larger, having the following dimensions: overall breadth, 125(145)170 µm; overall length, 103(123)130 µm; corpus length, 105(117)150 µm; corpus breadth, 81(103)111 µm. However, the Malanzán specimens are similar in size to those described by Gutiérrez (1993), who noted that size differences can be interpreted as infraspecific variability. Among the three morphotypes of *Colpisaccites granulosus* identified by Gutiérrez (1993), two (A and B) were recognized during the present study. These morphotypes differ in the degree of separation of the exine (more marked in A).
Previous records. Pennsylvanian: Argentina, Paganzo Basin, Agua Colorada Formation (Limarino and Gutiérrez, 1990; Gutiérrez, 1993). Lower Permian: Argentina, San Rafael Basin, Yacimiento Los Reyunos Formation (Césari *et al.*, 1996), Chacoparaná Basin (Archangelsky and Gamerro, 1979); Uruguay, San Gregorio Formation (Gutiérrez *et al.*, 2006).

Genus ***Peppersites*** Ravn 1979

Type species. *Peppersites ellipticus* Ravn 1979.

Peppersites sp. cf. ***P. ellipticus*** Ravn 1979
Figure 5.1, 4

Description. Pollen grains bilateral, monosaccate. Amb transversely oval to elliptical. Corpus outline (in polar view) closely conformable, dark, without folds. Laesurae rarely discernible. Saccus finely infrareticulate, approximately 1/10 of central body.
Dimensions. Overall breadth: 135-166 µm, overall length: 102-148 µm, corpus length: 115-154 µm, corpus breadth: 84-125 µm, saccus breadth: 6-12 µm (5 specimens).
Comparisons. This monotypic pollen genus is characterized chiefly by its large corpus. The specimens studied differ from *Peppersites ellipticus* in having a corpus slightly narrower than the overall breadth.
Previous records. Pennsylvanian: Brazil, Amazonas Basin, Tapajós Group (Playford and Dino, 2000); U.S.A. (Ravn, 1979, 1986; Ravn and Fitzgerald, 1982).

Characteristics of the palynological assemblages

The palynomorphs recovered from the Malanzán Formation are generally well-preserved and moderately diverse. Relative abundance of pollen grains is comparable between Section 3 (13-29 %) and Section 4 (12-24 %). The marine elements and algae species are very scarce, representing less than 1% of the total assemblage, and were recognized only in Section 4.

In his study of six samples of the Malanzán Formation in the Sierra de los Llanos area, Azcuy (1975a, b) recognized 19 spore species and two pollen species. Based on those identifications, Azcuy suggested an early Namurian age for the formation. More recently, Gutiérrez and Limarino (2001) studied black shale samples of this unit (from Section 3 of the present study), providing a more complete palynological inventory, with the identification of 41 species of spores and 11 of pollen grains (the latter unillustrated). These authors postulated a late Namurian-early Westphalian for the association and described marine elements for the first time from the unit. The palynological assemblages of the Malanzán Formation were referred by Césari and Gutiérrez (2001) to the *Raistrickia densa-Convolutispora muriornata* Biozone (Serpukhovian-Stephanian).

The studied assemblages comprise a total of 37 spore species (all trilete) distributed among 23 genera. Eleven genera and 19 species of pollen grains are identifiable; of these, bilateral or radial monosaccate pollen grains (17 species) predominate, whereas only two species are bisaccate. As in Azcuy´s (1975a, b) pioneering work on the formation, taeniate pollen grains were not recognized in the current study. However, Gutiérrez and Limarino (2001) have identified a specimen of *Striatites* sp. in a sample collected from the here-designated Section 3.

Thirty-five species are identified herein for the first time from the Malanzán Formation; viz., *Apiculatisporis variornatus*, *Apiculiretusispora alonsoi*, *Caheniasaccites densus*, *Colpisaccites granulosus*, *Costatascyclus crenatus*, *Cristatisporites inconstans*, *C. rollerii*, *Cyclogranisporites firmus*, *C. plicatus*, *C. rinconadensis*, *Dibolisporites disfacies*, *Divarisaccus stringoplicatus*, *Grossusporites microgranulatus*, *Leiotriletes tiwarii*, *Limitisporites rectus*, *Microreticulatisporites punctatus*, *Plicatipollenites gondwanensis*, *P. trigonalis*, *Potonieisporites barrelis*, *P. densus*, *P. neglectus*, *Punctatisporites gretensis*, *P. irrasus*, *P. priscus*, *Reticulatisporites magnidictyus*, *Verrucosisporites andersonii*, *Granulatisporites* sp. cf. *G. austroamericanus*, *Peppersites* sp. cf. *P. ellipticus*, *Potonieisporites* sp. cf. *P. jayantiensis*, *Raistrickia* sp. cf. *R. radiosa*, *Cristatisporites* sp., *Endosporites* sp. *Grandispora* sp., *Retusotriletes* sp. 1, and *Retusotriletes* sp. 2. This increases appreciably the number of reported Malanzán species.

Organic-walled microfossils identified as *Tetraporina punctata* are referred to the charophycean algal Family Zygnemataceae, which is interpreted by several authors (e.g., Colbath and Grenfell, 1995; Grenfell, 1995; Geel and Grenfell, 1996) as a freshwater inhabitant. On the other hand, the presence of *Navifusa* is a likely indicator of marine environments, and *Botryococcus* occurs in habitats of variable salinity as well as in freshwater or brackish environments (Guy-Ohlson, 1992; Brenner and Foster, 1994; Batten and Grenfell, 1996). The presence of these palynomorphs reinforces the interpretation of a transitional, fjord-type depositional environment, as previously suggested (Buatois and Mangano, 1995; Gutiérrez and Limarino, 2001; Limarino *et al*. 2002).

Comparison and age of the association

Several spore-pollen species typically found in Mid Carboniferous sequences of Argentina and Brazil occur in the studied samples. The most important are *Apiculatisporis variornatus*, *Apiculatasporites parviapiculatus*, *Apiculiretusispora alonsoi*, *Convolutispora muriornata*, *Raistrickia densa*, *Reticulatisporites passaspectus*, *Plicatipollenites malabarensis*, *P. trigonalis*, *P. gondwanensis*, *Potoniesporites barrelis*, *P. brasiliensis*, *P. densus*, *P. magnus*, *P. neglectus*, *Circumplicatipollis plicatus*, and *Crucisaccites monoletus*. The presence of pollen grains in the Malanzán Formation supports an age not older than Serpukhovian, because the first worldwide records of pollen grains occur in this uppermost Mississippian stage (Brugman *et al*., 1985; Loboziak and Clayton, 1988; Clayton *et al*., 1990; Zhu, 1993; Clayton, 1995).

Based on its palynological content, the Malanzán Formation is referred to the *Raistrickia densa-Convolutispora muriornata* Biozone (DM), proposed for western Argentina by Césari and Gutiérrez (2001). Furthermore, the scarcity of taeniate pollen grains would suggest a restriction to the Sub-Biozone A of the DM Biozone, dated as Serpukhovian (Césari and Gutiérrez, 2001; Gutiérrez *et al*., 2003).

The studied palynoflora shows strong similarities to the assemblages described from the Agua Colorada, Guandacol and El Trampeadero formations; however, only broad similarities were found with those reported from the Lagares and Jejenes formations (figure 7). The palynoflora of the lower member of the Agua Colorada Formation at the Las Gredas locality (Limarino and Gutiérrez, 1990) shares with the Malanzán assemblages stratigraphically important spore species such as *Convolutispora muriornata*, *Reticulatisporites asperidictyus* and *R. magnidictyus*, together with an important complement of pollen species (figure 7, 1A). Assemblages from the upper part of the Agua Colorada Formation differ in containing taeniate pollen grains (Gutiérrez, 1993). The Guandacol Formation's assemblages (Césari and Vázquez-Nístico, 1988; Ottone and Azcuy, 1990; Ottone, 1991; Césari and Limarino, 2002; Perez Loinaze, 2007) share with those of the Malanzán Formation a substantial number of spore species. These are *Anapiculatisporites concinnus*, *Apiculatisporis variornatus*, *Apiculiretusispora alonsoi*, *Convolutispora muriornata*, *Cyclogranisporites rinconadensis*, *C. firmus*, *Dibolisporites disfacies*, *Raistrickia densa*, *Reticulatisporites asperidictyus*, and *R. magnidictyus* (figure 7). The palynoflora described by Gutiérrez and Barreda (2006) from the El Trampeadero Formation (La Cébila Creek, La Rioja Province) shares several spore species with the Malanzán assemblages, including *Convolutispora muriornata*, *Raistrickia densa*, *Dibolisporites disfacies*, *Reticulatisporites asperidictyus*, *R. magnidictyus*, and many pollen species (figure 7). Only a few species are shared between the Malanzán and the lower part of the Lagares Formation: *Apiculatasporites caperatus*, *Apiculiretusispora ralla*, *Cannanoropollis densus*, and *C. mehtae* (Menéndez and Azcuy, 1969, 1971, 1973; Azcuy and Gutiérrez, 1983; see figure 7). On the other hand, *Convolutispora muriornata* and *Anapiculatisporites concinnus* (=*Anapiculatisporites argentinensis*) are the only two species in common between the former unit and the middle and upper sections of the Lagares Formation (Césari and Gutiérrez, 1985; Gutiérrez and Césari, 1989). In addition, as shown in figure 7 and by reference to González-Amicón (1973), Gutiérrez and Césari (1987), and Césari and Bercowski (1997), six species are shared with the palynofloras reported from the lower sections of the Jejenes Formation (e.g., *Apiculatisporis variornatus*, *Grossusporites microgranulatus* and *Reticulatisporites asperidictyus*); and a further seven species from the upper section (*Apiculatasporites caperatus*, *Apiculiretusispora ralla*, *Cannanoropollis densus*, *Convolutispora muriornata*, *Microreticulatisporites punctatus*, *Plicatipollenites malabarensis* and *Punctatisporites gretensis*).

The palynological assemblages recovered from the Guandacol and Trampeadero formations and those from the lower part of the Jejenes, Lagares and Agua Colorada formations were included in the Subzone A of the DM Biozone, characterized by the presence of *Convolutispora muriornata* and *Raistrickia den-*

	1		2		3		4	5
	A	B	A	B	A	B		
Anapiculatisporites concinus	X						X	X
Apiculatasporites caperatus	X			X	X			
Apiculatisporis variornatus			X				X	X
Apiculiretusispora alonsoi							X	X
Apiculiretusispora ralla		X		X	X			X
Caheniasaccites densus		X						
Cannanoropolis densus	X	X		X	X		X	X
Cannanoropolis janakii		X					X	
Cannanoropolis mehtae	X	X			X		X	X
Circumplicatipollis plicatus	X	X	X				X	X
Colpisaccites granulosus	X	X						
Convolutispora muriornata	X	X		X			X	X
Cristatisporites insconstans							X	X
Cristatisporites menendezii	X	X						X
Cristatisporites rollerii	X						X	X
Cristatisporites stellatus	X						X	X
Crucisaccites monoletus	X	X					X	X
Cyclogranisporites rinconadensis							X	
Cyclogranisporites firmus							X	
Dibolisporites disfacies							X	X
Dictyotriletes cortaderensis	X							x
Divarisaccus stringoplicatus							X	
Granulatisporites austroamericanus	X						X	X
Grossusporites microgranulatus	X		X				X	X
Indotriradites volkheimeri			X					X
Leiotriletes tiwarii							X	x
Limitisporites rectus		X					X	
Microreticulatisporites punctatus					X			
Plicatipollenites gondwanensis	X	X					X	X
Plicatipollenites trigonalis	X	X					X	
Plicatipollenites malabarensis	X	X		X	X		X	X
Potonieisporites barrelis	X	X					X	
Potonieisporites densus	X	X					X	
Potonieisporites magnus	X	X					X	
Potonieisporites neglectus	X	X					X	
Punctatisporites gretensis	X		X	X			X	X
Punctatisporites glaber	X				X		X	
Raistrickia paganciana							X	
Raistrickia rotunda	X						X	X
Reticulatisporites asperidictyus	X		X				X	X
Reticulatisporites magnidictyus	X						X	X
Tetraporina punctata	X							X
Vallatisporites ciliaris	X						X	X
Verrucosisporites andersonii							X	

Figure 7. Stratigraphic distribution of the identified species/ *distribución estratigráfica de las especies identificadas*: **1=** Agua Colorada Formation / *Formación Agua Colorada*, **A-** Lower member / *miembro inferior* (Azcuy *et al*., 1982; Limarino *et al*., 1984; Limarino and Gutiérrez, 1990; Vergel and Luna, 1992, Gutiérrez, 1993; Vergel *et al*., 1993), **B-** Middle and upper sections / *sección media y superior* (Menéndez, 1965; Menéndez and González-Amicón, 1979; Gutiérrez, 1993); **2=** Jejenes Formation / *Formación Jejenes*, **A-** Lower section / *sección inferior* (Césari and Bercowski, 1997), **B-** Middle and upper sections / *sección media y superior* (González-Amicón, 1973; Gutiérrez and Césari, 1987); **3=** Lagares Formation / *Formación Lagares*, **A-** Lower section / *sección Inferior* (Menéndez and Azcuy, 1969, 1971, 1973; Azcuy and Gutiérrez, 1983), **B-** Middle and upper sections / *sección media y superior* (Césari and Gutiérrez, 1985, Morelli *et al*., 1984; Gutiérrez and Césari, 1989); **4=** Guandacol Formation / *Formación Guandacol* (Césari and Vázquez-Nístico, 1988; Ottone and Azcuy, 1990; Ottone, 1991; Césari and Limarino, 2002; Perez Loinaze, 2007); **5=** Trampeadero Formation / *Formación Trampeadero* (Barreda, 1986; Moreno, 1993; Bossi, 1999; Gutiérrez and Barreda, 2006).

sa and the absence of striate pollen grains (Césari and Gutiérrez, 2001).

It is noteworthy that *Reticulatisporites magnidictyus* was widely reported in the late Viséan, but in Argentina occurs in younger palynofloras (Serpukhovian) belonging to Subzone A of the DM Biozone (e.g., Limarino and Gutiérrez, 1990; Ottone, 1991; Gutiérrez and Barreda, 2006; Perez Loinaze, 2007). Other species that may also have stratigraphic significance are *Reticulatisporites asperidictyus* and *Dibolisporites disfacies* recently identified in assemblages referred to the DM Biozone (e.g., Gutiérrez and Limarino, 2001; Gutiérrez and Barreda, 2006; Perez Loinaze, 2007).

Souza (2006) proposed two new interval biozones for Pennsylvanian deposits of the northeastern Paraná Basin. The older, the *Ahrensisporites cristatus* Biozone (dated as late Bashkirian to Kasimovian), shares with the Malanzán palynoflora many species, such as *Anapiculatisporites concinnus* (=*Anapiculatisporites argentinensis*), *Cristatisporites menendezii*, *Raistrickia rotunda*, *R. paganciana*, *Convolutispora muriornata*, and some pollen species, but differs in its content of taeniate pollen grains (*Protohaploxypinus*).

Jones and Truswell (1992) identified five Oppel-zones in the Joe Joe Group of the Galilee Basin, Australia. The oldest, the *Verrucosisporites basiliscutis* Oppel-zone dated as early Namurian, shares with the Malanzán palynoflora only two species (i.e., *Cannanoropollis janakii* and *Cyclogranisporites firmus*). The slightly younger *Brevitriletes leptoacaina* Oppel-zone (Namurian-?early Westphalian) has only one species (*D. disfacies*) in common with the Malanzán assemblages. Both Australian Oppel-zones are characterized, as the Malanzán palynoflora, by the complete absence of taeniate pollen grains.

The base of the Australian *Spelaeotriletes ybertii* Assemblage (Kemp *et al*., 1977) and the *Diatomozonotriletes birkheadensis* Assemblage (Powis, 1984) are marked by the first appearance of monosaccate pollen grains. However, occurrence of taeniate pollen grains in these Australian *Spelaeotriletes ybertii* and *Diatomozonotriletes birkiadensis* assemblages preclude their correlation with the Malanzán palynoflora.

Conclusions

A total of 37 spore and 19 pollen species have been identified in the analysed samples of the Malanzán

Formation, as exposed at the La Chimenea locality in the Olta valley and at the Cuestita de la Herradura locality in the Malanzán valley. Thirty-five species of these species have not been recovered so far from the Malanzán Formation. Furthermore, pollen grains are illustrated for the first time for this unit.

The co-occurrence of the stratigraphically significant spore species as *Convolutispora muriornata* and *Raistrickia densa*, and a great number of pollen species, clearly indicate a Serpukhovian age for the Malanzán Formation, and confirms (apropos of Césari and Gutiérrez, 2001) its attribution to the Sub-Biozone A of the *Raistrickia densa-Convolutispora muriornata* Biozone. The Malanzán palynoflora can be correlated with those described from the Guandacol and El Trampeadero formations, and with those from the lower parts of the Jejenes, Lagares and Agua Colorada formations.

The scarce presence of *Navifusa* sp., together with brackish water algae and the predominance of terrestrial palynomorphs testified the interpretation of the Malanzán Formation as deposited in a fjord environment.

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