AMEGHINIANA (Rev. Asoc. Paleontol. Argent.) - 42 (2): 481-488. Buenos Aires, 30-06-2005 ISSN 0002-7014

Some trilete spores from Lower Carboniferous strata of the Rio Blanco Basin, western Argentina

Valeria PEREZ LOINAZE[1]

Abstract. A new miospore genus *Ductilispora* is described to accommodate simple acamerate miospores, which have a distal ornament of folds like muri or thickenings. Five new species of trilete spores are defined: *D. circularis* sp. nov., *D. longitudinalis* sp. nov., *D. corrugatus* sp. nov., *Verrucosisporites cortaderensis* sp. nov., *Dibolisporites malimanensis* sp. nov. and *Indotriradites variabilis* sp. nov. The specimens have been recovered from the Malimán and the Cortaderas Formations (Early Carboniferous), in La Cortadera creek, San Juan province, Argentina.

Resumen. ALGUNAS ESPORAS TRILETES DE ESTRATOS DEL CARBONÍFERO INFERIOR DE LA CUENCA DE RÍO BLANCO, OESTE DE ARGENTINA. En este trabajo se propone el género *Ductilispora* nov. gen. para miosporas acavadas, con escultura distal compuesta por pliegues similares a muros o engrosamientos. También se designan cinco nuevas especies: *D. circularis* sp. nov., *D. longitudinalis* sp. nov., *D. corrugatus* sp. nov., *Verrucosisporites cortaderensis* sp. nov., *Dibolisporites malimanensis* sp. nov., e *Indotriradites variabilis* sp.nov. Estas formas provienen de secuencias del Carbonífero Inferior (Formaciones Malimán y Cortaderas) que afloran en la quebrada de La Cortadera, al este de la provincia de San Juan, República Argentina.

Key words. Palynology. Cortaderas Formation. Malimán Formation. Lower Carboniferous. San Juan. Argentina.

Palabras clave. Palinología. Formación Malimán. Formación Cortaderas. Carbonífero Inferior. San Juan. Argentina.

Introduction

The Río Blanco Basin is located in western Argentina (La Rioja and San Juan provinces) and comprises the Angualasto Group defined by Limarino and César i (1992). This Early Carboniferous unit includes, among others, the Malimán and Cortaderas Formations, both represented at its type locality (La Cortadera creek).

These sequences are characterized by predominant marine sedimentation (Lopez Gamundi *et al*, 1987). The outcrops of the Malimán Formation in La Cortadera creek, reach a thickness of 1188 m, unconformably overlying the Devonian Chigua Formation, and have an abundant record of plant remains (Frenguelli, 1954; Menéndez, 1965; Azcuy *et al*., 1980; César i, 1988; Sessarego and César i, 1989; Arrondo *et al*., 1991). This paleoflora was referred to the *Archaeosigillaria-Frenguellia* Biozone and an Early Carboniferous age was suggested (Sessarego and César i, 1989). César i and Limarino (1995) recorded a rich palynological association from the Malimán Formation and proposed a Tournaisian age for this sequence. These assemblages, deposited on a low energy marine plataform, are characterized by the presence of smooth, verrucate and cingulizonate spores, along with scarce acritarchs. The invertebrate association was studied by Amos, 1958; Amos *et al*., 1973 and Antelo, 1969, and a marine biozone named *Protocanites* (González, 1981) or Fauna Malimaniana (González, 1993) was defined and regarded as Tournaisian in age. Later, Sabattini *et al*. (2001) proposed a new bioestratigraphic zone: *Protocanites scalabrinii-Paurohynchia chavelensis*, suggesting an Early Carboniferous age for the unit. Recently, Rodriguez Amenabar *et al*. (2003) recognized Devonian reworked specimens in the palynological assemblages from the basal conglomerates of the Malimán Formation.

The Cortaderas Formation is 1160 m thick in its type locality, and unconformably overlies the Malimán Formation. This unit was originally regarded as Late Carboniferous-Permian by Scalabrini Ortiz (1970, 1973), and was assigned to the Early Carboniferous on the basis of palynological data by Limarino and César i (1992). According to these authors, its sedimentation occurred mainly during the Early Carboniferous, but they also suggested that its upper levels most probably could reach the Late Carboniferous. Carrizo (1990) reported the Late Carboniferous NBG Biozone at the top of this Formation, while César i and Limarino (1993) described palynological associations including continental and marine species from the lower and middle sections of this unit.

[1]División Paleobotánica, Museo Argentino de Ciencias Naturales "Bernardino Rivadavia". Av. Angel Gallardo 470 C1405DJR, Buenos Aires, Argentina. *loinazev@macn.gov.ar*

©Asociación Paleontológica Argentina AMGHB2-0002-7014/05$00.00+.50

The aim of the present paper is to describe, illustrate and revise some trilete spore species that are characteristic components of the Malimán and the Cortaderas Formations. All species described here, with exception of *D. corrugata* (restricted to Cortaderas Fm.) appear in all the sequence. At present it is assumed that these species are authochthonous.

Material and methods

This paper is based on 11 palynological samples from the Cortaderas Formation and 5 from the Malimán Formation, all from La Cortadera Creek (about 29º 45´S 69º 02´W) in the western flank of the sierra de la Punilla, San Juan province. Some of these samples are those originally studied by Césari and Limarino (1993, 1995) and were revised for the present analysis. Laboratory procedures for extraction and concentration of palynomorphs followed conventional practices. Carbonates and silicates were removed by treatment with hydrochloric and hydrofluoric acids. The palynological residues were sieved on a 17 µm mesh and mounted on unstained glycerin jelly. The photographs were taken with a Nikon Coolpix 995 adapted to an Olympus BX 51 binocular microscope. All illustrated specimens are deposited in the palynological Collection of the Museo Argentino de Ciencias Naturales "Bernardino Rivadavia" (BA Pal) and are identified with England Finder coordinates.

The suprageneric classification of spores follows the classical scheme of Dettmann (1963).

Systematic paleontology

Anteturma PROXIMEGERMINATES R. Potonié 1970
Turma TRILETES Reinsch *emend*. Dettmann 1963
Suprasubturma ACAVATITRILETES Dettmann 1963
Subturma AZONOTRILETES Luber *emend*. Dettmann 1963
Infraturma MURORNATI Potonié and Kremp 1954

Genus ***Ductilispora*** gen. nov.

Type species. *Ductilispora circularis* sp. nov.

Diagnosis. Spores radial, trilete, acavate. Amb subcircular to roundly subtriangular or triangular with convex or straight sides. Laesurae straight, simple or with slight lip development, length at least one-half of spore radius. Proximal face with reduced sculpture or laevigate. Distal face sculptured with folds like muri or thickenings of regular or irregular arrangement, infrequently branched or anastomosed.

Derivation of name. From the latin *ductilis*, easily deformable.

Comparison. *Plicatispora* Higgs *et al*. 1988 is characterised by a distal face sculptured with folds, and fine muri, but is distinguishable from *Ductilispora* gen. nov. in having laesurae extending almost to the spore margin and terminating into curvaturae. *Amicosporites* Cramer 1966, from the Upper Silurian of Spain, has a distal circular ridge, but differs by the fairly regular thickening, constantly annular. *Knoxisporites* Potonié and Kremp 1954 resembles the new taxon in having distal thickenings, but this genus was originally defined with a characteristic more o less uniform cingulum. *Camptotriletes* Naumova 1939 is distinguishable from *Ductilispora* gen. nov. by its sculpture with irregular and rather shapeless ridges of uneven irregular height (rudimentary cristae) or randomly placed welts that in part branch, and grade into rudimentary cristae.

Ductilispora circularis sp. nov.
Figures 1.A-F

Holotype. BA Pal 5406: T39/3, figures 1.A-B.

Diagnosis. Spores radial, trilete. Amb subcircular to suboval. Laesurae straight, with slight lip development; length at least three-quarters of spore radius. Distal face coarsely sculptured with a prominent ring-like thickening, more or less continuous (4-6 µm wide), fairly irregular in form, approximately conformable with amb. The thickened and unthickened exine is laevigate, 1.5-2 µm thick.

Dimensions. 38(55)65 µm (14 specimens).

Type locality and horizon. La Cortadera Creek, San Juan province, Argentina. Malimán Formation, Lower Carboniferous.

Distribution. Malimán and Cortaderas Formation, Lower Carboniferous.

Derivation of name. From latin *circularis*, of circular shape.

Comparison. *Amicosporites splendidus*, as described by Cramer (1966) from the Upper Silurian and Devonian of Spain, shows some resemblance to *Ductilispora circularis* sp. nov., but differs in having more regular annular ridges, laesurae extending to margin, thinner exine and amb rounded triangular. *Ductilispora circularis* sp. nov. resembles *Knoxisporites ruhlandii* Doubinger and Rauscher 1966, *K.* sp. cf. *K. ruhlandii* in Playford 1971 and *K. stephanephorus* Love 1960, but is distinguishable by lacking a cingulum. Moreover, *K. ruhlandii* and *K.* sp. cf. *K. ruhlandii* have a rounded boss-like exinal elevation of the distal polar region. On the other hand, *K. stephanephorus*, a species that is well known from Visean-Lower Namurian sediments of Britain and U.S.A., has two thickened rings equatorially, with interrradial connections, a thickened region on the distal pole and lips that broaden towards the equator. *Dillspora disjunta* (Neville in Neves *et al*., 1973) Neville 1989 differs in having distal thickened polar boss and subpolar thickened ring, both of which may be variably developed, and an equatorial extension of the exine

which is widest interradially, being reduced or absent at the apices.

Ductilispora longitudinalis sp. nov.
Figures 1.G-L

Holotype. BA Pal 5405: W39/0, figures 1.G-H.

Diagnosis. Spores radial, trilete. Amb subcircular to suboval. Laesurae straight, with slight lip development; length at least three-quarters of spore radius. Distal face bearing one, more o less regularly disposed, transverse, central muri or thickening (2-4.5 µm wide al base, 3-7 µm high), length c. three-quarters of the spore radius, usually straight but sometimes strongly curved. Non-murornate exine laevigate to infragranulate, 1.5-2 µm thick.
Dimensions. Equatorial diameter 41(55)78 µm (23 specimens).
Type locality and horizon. La Cortadera Creek, San Juan province, Argentina. Malimán Formation, Lower Carboniferous.
Distribution. Malimán and Cortaderas Formation, Lower Carboniferous.
Derivation of name. From latin *longitudinalis*, relative to the length.
Comparison. *Knoxisporites pristicus* Sullivan 1968 is the most similar species, but this Tournaisian species differs in having ill defined thickening and a perceptible cingulum. *Knoxisporites dissidius* Neves 1961 is characterised by a hexagonal tendency of the equatorial outline, the slightly discordant fleshy cingulum and the pattern of distal thickenings.

Ductilispora corrugata sp. nov.
Figures 1.M-O

Holotype. BA Pal 5789: M 45/4, figures 1.M-N.

Diagnosis. Spores radial, trilete. Amb circular to subcircular. Laesurae straight, simple, extending to or almost to equator. Distal face sculptured with loosely distributed, smooth, rounded and low muri or thickenings infrequently branched and irregularly vermiculate (2-3 µm wide) and not closely packed overlapping. The thickened and unthickened exine is laevigate, 1.5-2.5 µm thick.
Dimensions. 48(58)70 µm (16 specimens).
Type locality and horizon. La Cortadera Creek, western San Juan province, Argentina. Cortaderas Formation, Lower Carboniferous.
Distribution. Cortaderas Formation, Lower Carboniferous.
Derivation of name. From latin *corrugatus*, corrugated, crumpled irregularly.
Comparison. *Convolutispora superficialis*, described by Felix and Burbridge (1967) from the Upper Mississippian to Lower Pennsylvanian of southern Oklahoma, resemblances *Ductilispora corrugata* sp. nov. However it is distinguishable by having indistinctly defined sculpture, forming weak convolutions; the elevated portions are broad with little sinuosity or ramification evident, weakly delimited lumina usually elongated, slight lips development and a thicker exine. *Convolutispora vermiformis* Hughes and Playford 1961 from the Late Devonian and Visean-Namurian has more coarsely lophate to lophoreticulate ridges, 4-12 µm in basal diameter and 4-6 µm high. *D. corrugata* sp. nov. is not included in the genus *Convolutispora* because its sculpture is irregularly vermiculate and not closely packed overlapping anastomosing. *Knoxisporites literatus* (Waltz) Playford 1963, differs by having a cingulum and distal surface bearing a few, coarse, irregular or regularly disposed muri enclosing broad lumina.

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

Genus ***Verrucosisporites*** Ibrahim *emend.* Smith 1971

Type species. *Verrucosisporites verrucosus* Ibrahim 1933.

Verrucosisporites cortaderensis sp. nov.
Figures 1.P-S

Holotype. BA Pal 5756: Y: 47/0, figure 1.P.

Diagnosis. Spores radial, trilete; concave-convex. Amb circular to subcircular, margin modified due to projection of sculptural elements. Laesurae straight, simple, length to or almost the equator. Distal face convex densely and uniformly sculptured with verrucae that are broadly rounded or flattened in cross section and subcircular to irregular in basal outline [0.8(2-3) 7µm wide at base, 1(1-2) 5 µm high]. Subordinate coni, rounded or with sharp apices, and grana (1-2 µm broad and high) are present in variable proportion among specimens. Proximal face concave, with reduced sculpture. Exine between sculpture laevigate.
Dimensions. 50(70)87 µm (39 specimens).
Type locality and horizon. La Cortadera Creek, San Juan province, Argentina. Cortaderas Formation, Lower Carboniferous.
Distribution. Malimán and Cortaderas Formation, Lower Carboniferous.
Derivation of name. From Cortaderas Formation, the stratigraphic unit where this species is more abundant.
Comparison. *Verrucosisporites morulatus* (Knox)

Smith and Butterworth 1967 is similar in having small proportion of conate, baculate and pilate sculptural elements, but differs by having originally spherical shape and the relatively loosely distributed sculptural elements. *Verrucosisporites grandis* McGregor 1960 is characterized by the sculpture with tendency towards biform elements at the equator and its bigger diameter. *Verrucosisporites baccatus* Staplin 1960 has irregularly disposed only grana and verrucae and is not concave-convex. *Verrucosisporites cerosus* (Hoffmeister, Staplin and Malloy) Butterworth and Williams 1958 is distinguishable by its sculpture including a proportion of pila which can only be seen at the margin.

Subinfraturma NODATI Dybová and Jachowicz 1957

Genus ***Dibolisporites*** Richardson *emend*. Playford 1976

Type species. *Dibolisporites echinaceus* (Eisenack) Richardon 1965.

Dibolisporites malimanensis sp. nov.
Figure 1.T and figures 2.A-C

Holotype. BA Pal 5401: V40/4, figures 2.A-B.

Diagnosis. Spores radial, trilete. Amb circular to subcircular. Laesurae straight, with membranous lips, extending to or almost to equator. Proximal face is rarely discernible, frequently missing or ruptured, when present is hyaline and psilate. Distal face and equatorial regions sculptured with biform elements, each element is compound of coni with rounded apices (0.8-4 µm in basal diameter, 1-3 high µm), subpolygonales in plan view, surmounted by a simple, bifurcate, trifurcate or multifurcate short spine (0.5-1.2 high µm). The proportion of different elements varies considerably between specimens. Sculptural elements discrete and separated by areas 0.2-0.5 µm wide. Exine about 0.5 µm thick.

Dimensions. Equatorial diameter 35(46)73 µm (87 specimens).

Type locality and horizon. La Cortadera Creek, San Juan province, Argentina. Malimán Formation, Lower Carboniferous.

Distribution. Malimán and Cortaderas Formation, Lower Carboniferous.

Derivation of name. From Malimán Formation, the stratigraphic unit where this species is more abundant.

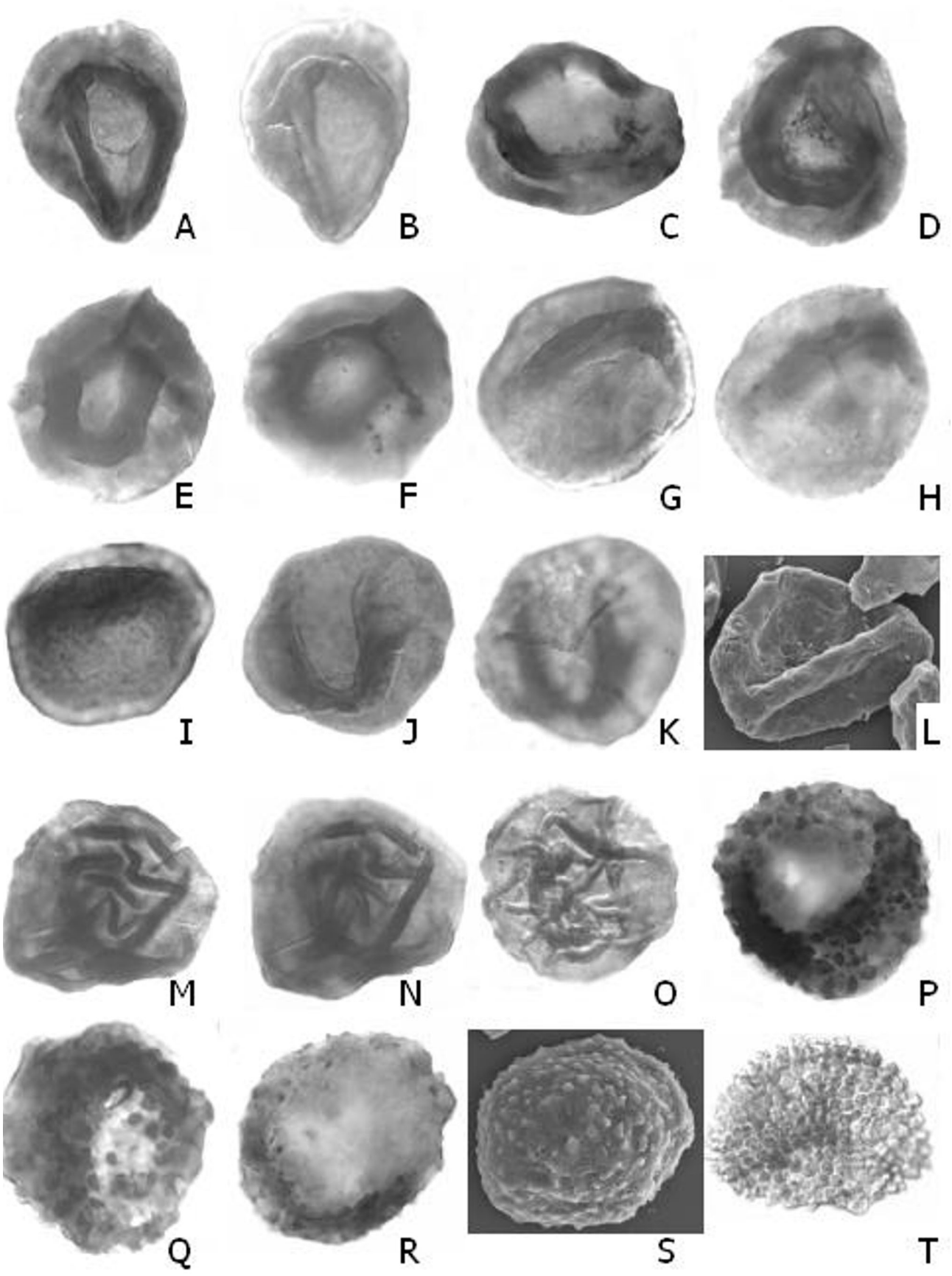
Comparison. The Late Carboniferous and Early Permian species, *Dibolisporites disfacies* Jones and Truswell 1992, differs from *Dibolisporites malimanensis* sp. nov. in being more regularly sculptured with biform elements composed of verrucae. *Dibolisporites microspicatus* Playford 1978 has lesser diverse sculpture, made by densely distributed biform elements of approximately hemispherical verrucae or grana surmounted by one (very rarely two) minute spines, and frequently coalescent in sinuous uniserial lines of up to 10 elements, or in groups of 3 or 4 elements and a thicker exine (1.3-1.8 µm). *Dibolisporites confertus* as described by Turnau and Jakubowska (1989), from the Early Devonian of central Poland, is similar to *Dibolisporites malimanensis* sp. nov., in having an ornament of densely set mammillate biform elements with often polygonal bases. However, the Polish species has more regular elements that rapidly taper and are surmounted by a very narrow spine. *Verrucosisporites poligonalis* Lanninger 1968 (p. 128, pl. 22-19) is ornamented by polygonal verrucae. *Verrucosisporites*? *polygonalis* Lanninger (in McGregor, 1973, p. 37-38, pl. 4-16, 17, 19, 25 and 26) is similar to *Dibolisporites malimanensis* sp. nov. in having biform elements but differs in the uniform sculpture.

Suprasubturma LAMINATITRILETES Smith and Butterworth 1967
Subturma ZONOLAMINATITRILETES Smith and Butterworth 1967
Infraturma CINGULICAVATI Smith and Butterworth 1967

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

Type species. *Indotriradites korbaensis* Tiwari 1964.

Figure 1. A-F, *Ductilispora circularis* sp. nov. **A-B,** holotype, Malimán Formation, BA Pal 5406: T39/3, x800/*Holotipo, Formación Malimán*. **A,** distal *view/vista distal*; **B,** proximal view /*vista proximal;* **C,** Malimán Formation, BA Pal 5403: K29/3, x600/ *Formación Malimán*; **D,** Malimán Formation, BA Pal 5403: H41/3, x700/ *Formación Malimán*; **E-F,** Cortaderas Formation, BA Pal 5756: K43/2, x600/*Formación Cortaderas*; **E,** distal view/ *vista distal*; **F,** proximal view/*vista proximal;* **G-L, *Ductilispora longitudinalis*** sp. nov.; **G-H,** holotype, Malimán Formation, BA Pal 5405: W39/0, x700/*holotipo, Formación Malimán;* **G,** distal view/*vista distal;* **H,** proximal view / *vista proximal;* **I,** Cortaderas Formation, BA Pal 5754: O59/2, x700/*Formación Cortaderas;* **J-K,** Malimán Formation, BA Pal 5407: K33/3, x800/*Formación Malimán*; **J,** distal view/*vista distal;* **K,** proximal view/*vista proximal;* **L,** MEB, Cortaderas Formation/*Formación Cortaderas*, x700; **M-O, *Ductilispora corrugatus*** sp. nov.; **M-N,** holotype, Cortaderas Formation, BA Pal 5789: M45/4, x800/h*olotipo, Formación Cortaderas;* **M,** distal view/ *vista distal;* **N,** proximal view/ *vista proximal;* **O,** Cortaderas Formation, BA Pal 5794: L44/0/*Formación Cortaderas;* **P-S,** *Verrucosisporites cortaderensis* sp. nov.; **P,** holotype, Cortaderas Formation, BA Pal 5756: Y47/0, x500/*holotipo, Formación Cortaderas;* **Q,** Cortaderas Formation, BA Pal 5756: R49/4, Ax600/*Formación Cortaderas;* **R,** Cortaderas Formation, BA Pal 5792: X37/0, x600/*Formación Cortaderas;* **S,** MEB, Cortaderas Formation, x800/*Formación Cortaderas;* **T, *Dibolisporites malimanensis*** sp. nov. Malimán Formation, BA Pal 5401: V40/4, distal view, x700/*Formación Malimán, vista distal.*


A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
R
S
T

Indotriradites variabilis sp. nov.
Figures 2.D-H

1987 *Hymenozonotriletes pseudoreticulatus* Azcuy and Ottone, plate 2, figure 1.
1993 *Hymenozonotriletes pseudoreticulatus* Césari and Limarino, plate 1, figure 10.
1995 *Hymenozonotriletes verrucosus* Césari and Limarino, plate 1, figure 10.
1996 *Grandispora pseudoreticulatus* Ottone, plate 3, figure 3.
1996 *Grandispora pseudoreticulatus* Ottone and Rosello, plate 1, figure 12.

Holotype. BA Pal 5409: L51/1, figures 2.E-F (originally illustrated by Césari and Limarino, 1995, plate 1, figure 10).

Diagnosis. Spores radial, trilete, cavate, zonate. Amb subtriangular with convex sides and rounded apices, occasionally subcircular. Laesurae straight to slightly sinuous, with lips lenght to or almost to equatorial margin or in some instances to the flange margin as slender folding, 2-4.5 µm high. Proximal face laevigate. Central body distally sculptured with basally fused, simple and biform coni and spine, 2-7 µm µm high and 1.5-3 µm in basal diameter, often basally coalescent to produce a roughly reticulate appearance in some specimens, but it is a variable character between specimens. Equatorial flange about 1/5-1/6 of spore radius, having fairly uniform width on same specimen, outer margin irregularly dentate due to projecting of coni, 1-2 µm broad basally and long. Zone usually sculptured with minute cone and spinae.
Dimensions. Equatorial diameter 96(118)180 µm, diameter central body 55(71)105 µm (46 specimens).
Type locality and horizon. La Cortadera Creek, San Juan province, Argentina. Malimán Formation, Lower Carboniferous.
Distribution. This species, described originally from late Givetian-Early Frasnian age from Argentina (Ottone, 1996), has been subsequently reported from late Givetian-Early Frasnian age from Bolivia (Ottone and Rossello, 1996) and Early Carboniferous from Bolivia (Azcuy and Ottone, 1987), Malimán and Cortaderas Formation.
Derivation of name. From latin *variabilis*, that varies or can vary.
Comparison. In seeking an appropriate generic assignment of the studied specimens, several possibilities were analised. *Kraeuselisporites* as redefined by Scheuring (1974) is invariably acavate. *Cristatisporites* (Potonie and Kremp) Butterworth *et al*. 1964 has cristate, often biform sculpture and a cingulizona. *Indotriradites* as originally defined (Tiwari, 1964), subsequently enmended by Foster, 1979 and following other authors as Loboziak *et al*. (1999), is cavate (intexinal layer separated, at least distally and equatorially, from exoexine by a broad or narrow cavum), with the exoexine extended equatorially in a zona and bearing distal sculpturae. Therefore, the species here described is undoubtedly assignable to *Indotriradites*.

Hymenozonotriletes pseudoreticulatus, which was described by Menéndez and Pöthe de Baldis (1967) from the Middle Devonian of the Picuiba 1 boring of Paraguay, shows closest resemblance with *Indotriradites variabilis* sp. nov. However, that species was originally considered as acavate and characterized by a central body sculptured by concentric irregular ridges, partly anastomosed producing a roughly reticulate appearance. Taking into account that *I. malimanensis* is cavate, with the distal sculpture usually discrete and that all the original material of *H. pseudoreticulatus* is lost, a new specific taxon is here proposed.

Nevertheless, some specimens from southern Devonian-Lower Carboniferous sequences, which are very similar to the ones here described, were referred to *H. pseudoreticulatus* (Azcuy and Ottone, 1987; Ottone and Rosello, 1996; Ottone, 1996). Some of that material could be examined and indeed resembles Cortaderas and Malimán´s specimens. Ottone (1996) transferred *H. pseudoreticulatus* to the genus *Grandispora*, but this combination is here considered unsuitable. *Grandispora*, according to the emendation of McGregor 1973, and the usual use by several authors (Playford, 1991; Loboziak *et al*., 1999; Higgs *et al*., 2000, among others), includes cavate spores, with exoexine predominantly sculptured on all the distal face, which may also extend onto equatorial portions of the proximal surface. However, some species with a distinctive flange and sculpture located mainly on the central body have been included in this genus, for example, *G. macrotuberculata* (Arkangelskaya) McGregor 1973, which do not fit within the original generic diagnosis.

Among the known species of *Indotriradites*, *I. dolianitii* Loboziak *et al.* 1999 has smaller diameter, larger and closer spaced elements on or around the inner margin of zona and faint radial plication on the zona. *Indotriradites daemonii* Loboziak *et al*. 1999 differs by having smaller sculpture and dense radial plication on zona.

Conclusions

The palynological assemblages that characterize the Lower Carboniferous from western Argentina are assigned to the *Cordylosporites-Verrucosisporites* Biozone (Césari and Gutiérrez, 2001) that contains some conspicuous trilete spores which have been revised in detail in order to find their proper taxonomic affinities. The systematic analysis of the assemblages allowed the description of the new miospore genus *Ductilispora* with three new species.

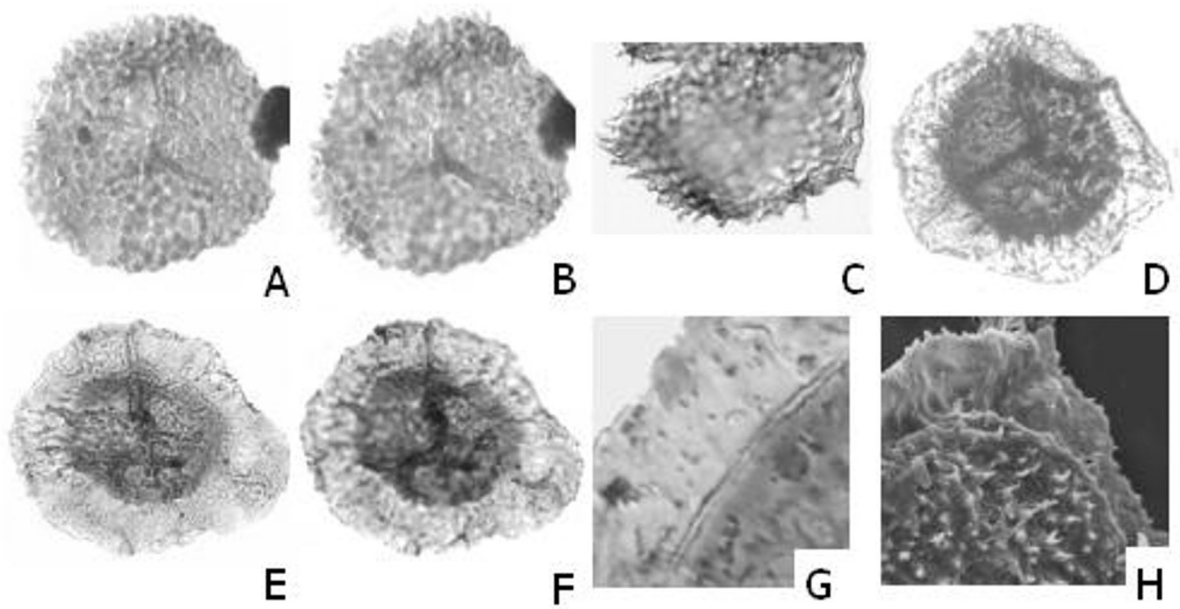


Figure 2. A-C, *Dibolisporites malimanensis* sp. nov. **A-B,** holotype, Cortaderas Formation, BA Pal 5754: A53/1, x 650/*holotipo, Formación Cortaderas;* **A,** distal view/*vista distal;* **B,** proximal view/*vista proximal;* **C,** Malimán Formation, BA Pal 5724: R28/0, x 550/*Formación Malimán;* **D-H, *Indotriradites variabilis*** sp. nov.; **D,** Malimán Formation, BA Pal 5401: Q29/3, x 270/*Formación Malimán;* **E-F,** holotype, Cortaderas Formation, BA Pal 5409: L51/1, x 270/*holotipo, Formación Cortaderas;* **E,** distal view/ *vista distal;* **F,** proximal view/ *vista proximal;* **G,** Cortaderas Formation, BA Pal G3-1: D49/3, picture shows the separation of exine layers, x630/*Formación Cortaderas, detalle de la separacion de las capas de la exina;* **H,** MEB, Cortaderas Formation, distal central body sculptural detail, x630/*Formación Cortaderas, detalle de la escultura distal del cuerpo.*

These simple acamerate miospores have a distal ornament of folds like muri or thickenings.

Moreover, three new species were assigned to the genera *Verrucosisporites*, *Dibolisporites* and *Indotriradites*, respectively. *Verrucosisporites cortaderensis* sp. nov. is characterized by concave-convex spores bearing a very variable sculpture. *Dibolisporites malimanensis* sp. nov. has biform elements; each element composed by coni, subpolygonal in plan, surmounted by a simple, bifurcate, trifurcate or multi-furcate spine. *Indotriradites variabilis* sp. nov. has partially fusioned biform coni and spines, and includes previously described specimens.

Acknowledgments

The author thanks S. Césari for reading the manuscript and for her valuable comments, and P. Gutiérrez and V. Barreda for making constructive criticisms. This paper is a contribution to the IGCP Project 471, "Evolution of Western Gondwana during the Late Paleozoic: Tectosedimentary record, paleoclimates, and biological changes".

References

Amos, A.J. 1958. Some Lower Carboniferous brachiopods from the Volcán Formation, San Juan, Argentina. *Journal of Paleontology* 32: 838-845.

Amos, A.J., Antelo, J.B., González, C.R., Mariñelarena, M.P. and Sabattini, N. 1973. Síntesis sobre el conocimiento bioestratigráfico del Carbónico y Pérmico de Argentina. *Revista de la Asociación Geológica Argentina* 40: 284-289.

Antelo, B. 1969. Hallazgo del género *Protocanites* (Ammonoidea) en el Carbónico Inferior de la provincia de San Juan. *Ameghiniana* 6: 69-73.

Arrondo, O., Césari, S.N. and Gutiérrez, R. 1991. *Frenguellia* a new genus of lycopods from the Early Carboniferous of Argentina. *Review of Palaeobotany and Palynology* 70: 187-197.

Azcuy, C. and Ottone, G. 1987. Datos palinológicos de la Formación Retama en la Encañada de Beu, Rio Alto Beni (Bolivia). *4º Congreso Latinoamericano de Paleontología* (Bolivia) 1: 235-249.

Azcuy, C., Césari, S.N. and Longobucco, M. 1980. Las plantas fósiles de la Formación El Ratón (provincia de San Juan). *Ameghiniana* 18: 11-28.

Butterworth, M.A. and Williams, R.W. 1958. The small spore floras of coals in the Limestone Coal Group and Upper Limestone Group of the Lower Carboniferous of Scotland. *The Royal Society of Edinburgh* 63: 353-392.

Butterworth, M.A., Jansonius, J., Smith, A.V.H. and Staplin, F.L. 1964. *Densosporites* (Berry) Potonié and Kremp and related genera. *5º Congrés International de la Stratigraphie et Géologie du Carbonifére* (Paris, 1963), *Comptes rendus* 1: 1049-1057.

Carrizo, H. 1990. Nuevos hallazgos de componentes de la flora NBG en la Formación Cortaderas, Precordillera, y en la Formación Las Salinas, Patagonia extraandina. *Annual Meeting Working Group, Project 211 (IUGS-UNESCO), Late Paleozoic of South America* (Buenos Aires), *Abstracts*: 93.

Césari, S.N. 1988. *Diphothmema bodenbenderi* Kurtz nov. comb. (Pteridospermales) del Carbonífero de Argentina. *Ameghiniana* 24: 263-269.

Césari, S.N. and Gutiérrez, P.R. 2001. Palynostratigraphy of Upper Paleozoic sequences in Central-Western Argentina. *Palynology* 24: 113-146.

Césari, S.N. and Limarino, C.O. 1993. Palinomorfos Eocarboníferos en la Formación Cortaderas, provincia de San Juan, Argentina. *8º Simposio Argentino de Paleobotánica y Palinología* (Corrientes), *Actas*: 45-48.

Césari, S.N. and Limarino, C.O. 1995. Primer registro palinológico de

la Formación Malimán (Carbonífero Inferior), Cuenca Río Blanco, Argentina. *6º Congreso de Paleontología y Bioestratigrafía* (Trelew), *Actas*: 77-83.

Cramer, F.H. 1966. Palynology of Silurian and Devonian rock in northwest Spain. *Boletín del Instituto Geológico y Minero de España* 77: 223-286.

Dettmann, M.E. 1963. Upper Mesozoic microfloras from south-eastern Australia. *Proceedings of the Royal Society of Victoria* 77: 1-148.

Doubinger, J. and Rauscher, R. 1966. Spores du Viséen marin de Bourbach-le-Haut dans les Vosges du Sud. *Pollen and Spores* 8: 361-405.

Felix, C.J. and Burbridge, P.P. 1967. Palynology of the Springer Formation of Souther Oklahoma, U.S.A. *Palaeontology* 10: 349-425.

Foster, C.B. 1979. Permian plant microfossils of the Blair Athol Coal Measures, Baralaba Coal Measures, and Basal Rewan Formation of Queensland. *Publication of the Geological Survey of Queensland* 372: 1-244.

Frenguelli, J. 1954. Plantas devónicas de la quebrada de La Charnela en la Precordillera de San Juan. *Notas del Museo de La Plata, Paleontología* 102: 359-376.

González, C. 1981. El Paleozoico superior marino de la República Argentina. Bioestratigrafía y Paleoclimatología. *Ameghiniana* 18: 51-65.

González, C. 1993. Late Paleozoic faunal succession in Argentina. *12º Congrès International de la Stratigraphie et Géologie du Carbonifère et Permien* (Argentina) *Comptes Rendus* 1: 537-550.

Higgs, K.T., Clayton, G., Keegan, J.B. 1988. Stratigraphic and Systematic Palynology of the Tournaisian Rocks of Ireland. *The Geological Survey of Ireland, Special Paper* 93 pp.

Higgs, K.T., Avkhimovitch, V. I., Loboziak, S., Maziane-Serraj, M. Stempien-Salek, M. and Streel, M. 2000. Systematic study and stratigraphic correlation of the *Grandispora* complex in the Famennian of northwest and eastern Europe. *Review of Palaeobotany and Palynology* 112: 207-228.

Hughes, N.F. and Playford, G. 1961. Palynological reconnaissance of the Lower Carboniferous of Spitsbergen. *Micropaleontology* 7: 27-44.

Ibrahim, A.C. 1933. [*Sporenformer des Agirhorizontes des Ruhr-Reviers: Konrad TriltschWurzburg* (Berlin): 47 pp. Unpublished Thesis.].

Jones, M.J. and Truswell, E.M. 1992. Late Carboniferous and Early Permian palynostratigraphy of the Joe Joe group, southern Galilee Basin, Queensland, and implications for Gondwana stratigraphy. *Journal of Australian Geology and Geophysics* 13: 143-185.

Lanninger, E.P. 1968. Sporen-Gesellschaften aus dem Ems der SW-Eifel (Rheinisches Schiefergebirge). *Palaeontographica* B 122: 95-170.

Limarino, C.O. and Césari, S.N. 1992. Reubicación estratigráfica de la Formación Cortaderas y definición del Grupo Angualasto (Carbonífero Inferior, Precordillera de San Juan). *Revista de la Asociación Geológica Argentina* 47: 61-72.

Loboziak, S., Streel M. and Melo, J. H. G. 1999. *Grandispora* (al. *Contagisporites*) *permulta* (Daemon, 1974) Loboziak, Streel et Melo, comb. nov., a senior synonym of *Grandispora riegelii* Loboziak et Streel, 1989-nomenclature and stratigraphic distribution. *Review of Palaeobotany and Palynology* 106: 97-102.

López Gamundí, O.R., Azcuy, C.L., Cuerda, A.J., Valencio, D.A. and Vilas, J.F. 1987. Cuencas Río Blanco y Calingasta-Uspallata. In: S. Archangelsky (ed.), El Sistema Carbonífero en la República Argentina. *Academia Nacional de Ciencias* (Córdoba), pp. 281-291.

Love, L.G. 1960. Assemblages of small spores from the Lower Oil-Shale Group of Scotland. *The Royal Society of Edinburgh* 67: 99-126.

McGregor, D.C. 1960. Devonian spores from Melville Island Canadian Artic Archipielago. *Palaeontology* 3: 26-44.

McGregor, D.C. 1973. Lower and Middle Devonian spores of eastern Gaspe, Canada. I. Systematics. *Palaeontographica* B 142: 1-77.

Menéndez, C.A. 1965. Contenido palinológico en sedimentos con *Rhacopteris ovata* (Mc Coy) Walk de la sierra de Famatina, La Rioja. *Revista del Museo Argentino de Ciencias Naturales Bernardino Rivadavia* 1: 45-80.

Menéndez, C.A. and Pöthe de Baldis, E.D. 1967. Devonian spores from Paraguay. *Review of Palaeobotany and Palynology* 1: 161-172.

Naumova, S.N. 1939. Spores and pollen of the coal of the U.S.S.R. *Reports of the 17º International Geological Congress* (Moscow) 1: 353-364.

Neves, R. 1961. Namurian plant spores from the southern Pennines, England. *Palaeontology* 4: 247-279.

Neves, R., Gueinn, K.J., Ioannides, N.S., Neville, R.S.W. and Kruszewska, K. 1973. Palynological correlations within the Lower Carboniferous of Scotland and Northern England. *Transactions of the Royal Society of Edinburgh* 69: 23-70.

Neville, R.S.W. 1989. Three new miospore genera from the Lower Carboniferous (Viséan) rocks of east Fife, Scotland. *Journal of Micropaleontology* 8: 103-107.

Ottone, E.G. 1996. Devonian palynomorphs from the Los Monos Formation, Tarija Basin, Argentina. *Palynology* 20: 101-151.

Ottone, E.G. and Rosello, E.A. 1996. Palinomorfos devónicos de la Formación Tequeje, Angosto del Beu, Bolivia. *Ameghiniana* 33: 443-451.

Playford, G. 1963. Lower Carboniferous microfloras of Spitsbergen-Part 2. *Palaeontology* 5: 619-678.

Playford, G. 1971. Lower Carboniferous spores from the Bonaparte Gulf Basin, Western Australia and Northern Territory. *Bulletin of the Bureau of Mineral Resources, Geology and Geophysics* 115: 1-105.

Playford, G. 1976. Plant microfossils from the Upper Devonian and Lower Carboniferous of the Canning Basin, Western Australia. *Paleontographica* B 148: 1-71.

Playford, G. 1978. Lower Carboniferous spores from the Ducabrook Formation, Drummond Basin, Queensland. *Palaeontographica* B 167: 105-160.

Playford, G. 1991. Australian Lower Carboniferous miospores relevant to extra-gondwanic correlations: an evaluation. *Courrier Forschungsinstitut Senckenberg* (1990) 130: 85-125.

Potonié, R. and Kremp, G. 1954. Die Gattungen der Paläozoischen Sporae dispersae und ihre Stratigraphie. *Geologisches Jahrbuch* 69: 111-194.

Richardson, J.B. 1965. Middle Old Red Sandstone spore assemblages from the Orcadiam Basin, norh- east Scotland. *Palaeontology* 7: 559-605.

Rodríguez Amenábar, C., di Pasquo, M. and Carrizo, H.A. 2003. Datos palinológicos del límite Devónico-Carbónico en la quebrada Cortaderas, provincia de San Juan, Argentina. *Ameghiniana Suplemento Resúmenes* 40: 24R.

Sabattini, N., Azcuy, C.L. and Carrizo, H.A. 2001. Invertebrados marinos de la Formación Malimán (Carbonífero inferior), y su relación con las asociaciones paleoflorísticas. Provincia de San Juan, Argentina. *Revista de la Asociación Geológica Argentina* 56: 111-120.

Scalabrini Ortiz, J. 1970. [*Litología, facies y procedencia del Carbónico marino en el norte de la Precordillera sanjuanina* (zona del Río Blanco). Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires: 123 pp. Unpublished Doctoral Thesis.].

Scalabrini Ortiz, J. 1973. El Carbónico en el sector sepentrional de la Precordillera sanjuanina. *Revista de la Asociación Geológica Argentina* 27: 351-377.

Scheuring, B. 1974. *Kraeuselisporites* Leschik and *Thomsonisporites* Leschik- a revision of the type material of two disputed genera. *Review of Paleobotany and Palynology* 17: 187-203.

Sessarego, H.L. and Césari, S.N. 1989. An Early Carboniferous flora from Argentina. Biostratigraphic implications. *Review of Palaeobotany and Palynology* 57: 247-264.

Smith, A.H.V. 1971. Le genere *Verrucosisporites* Ibrahim 1933. emend. In: *Microfossiles organiques du Paléozoique.* 4 Les Spores CIMP-CNRS (ed.) 2: 35-87.

Smith, A.H. and Butterworth, M.A. 1967. Miospores in the coal seams of the Carboniferous of Great Britain. *Special Papers in Palaeontology* 1: 1-324.

Staplin, F.L. 1960. Upper Mississippian plant spores from the Golata Formation, Alberta, Canada. *Palaeontographica* B 107: 1-40.

Sullivan, H.J. 1968. A Tournaisian spore flora from the Cementstone Group of Ayreshire, Scotland. *Palaeontology* 11: 116-131.

Tiwari, R.S. 1964. New miospore genera in the coals of Barakar Stage (Lower Gondwana) of India. *The Palaeobotanist* 12: 250-259.

Turnau, E. and Jakubowska, L. 1989. Early Devonian miopores and age of the Zwole´n Formation (Old Red Sandstone Facies) from Ciepielów IG-1 borehole. *Annales Societatis Geolorum Poloniae* 59: 391-416.

Recibido: 7 de junio de 2004.
Aceptado: 4 de noviembre de 2004.