Systematic study of Early Carboniferous palynological assemblages from the Llanos Orientales Basin, Colombia

Hernando DUEÑAS1 & Silvia N. CÉSARI2


Abstract: This paper concerns the description of palynomorphs recovered from subsurface Early Carboniferous strata of the SM-4 well located in the Llanos Orientales Basin, Colombia. Thirty-two species of spores are recognized within the palynoflora. A new species is proposed: Spelaeotriletes colombianus Dueñas and Césari sp. nov. The assemblages were referred to the Tournaisian-Viséan by the presence of distinctive spore species with previous records in the Viséan and Tournaisian of Western Europe and Western Gondwana.

Key words: Lower Carboniferous, palynology, Colombia.

The Colombian Llanos Basin is a structural depression located in the eastern part of Colombia (Fig.1). The sedimentary sequence, which fills this depression, is divisible into three time units palynologically dated as Paleozoic, Cretaceous and Tertiary. Early Carboniferous strata found in interval 2010-2340 ft of the SM-4 well yielded assemblages dominated by terrestrial palynomorphs (Dueñas & Césari, 2003). This is the only reference to Early Carboniferous sediments in the whole Llanos Basin. Stratigraphic data and miospore range distribution were discussed by Dueñas & Césari (in press). The aim of this paper is to describe the Early Carboniferous palynological assemblages from the SM-4 well of the Los Llanos Orientales Basin, Colombia.

MATERIAL AND METHODS

Ten cutting samples from interval 2010-2340ft of the borehole SM-4 yielded miospores and acritarchs. Laboratory preparation followed the standard techniques using fluorhidric and hydrochloric acids. Sample residues were mounted on microscope slides in Canada balsam and all slides are stored at the National Core Library, Colombian Petroleum Institute, Bucaramanga (Colombia). The preservation is variable within the samples, but frequently is poor to moderate, and the palynomorphs are thermally mature and display dark brown to black color. Miospore locations on slides are based on England Finder graticules.

SYSTEMATIC

**Genus Calamospora** Schopf, Wilson & Bentall, 1944

*Type species.* Calamospora hartungiana Schopf, Wilson & Bentall, 1944

**Calamospora liquida** Kosanke, 1950

(Fig. 2 P)

Description. Spores radial, trilete. Amb circular to subcircular. Laesurae simple, straight, extending three-quarters of spore radius. Exine laevigate, 1µm thick, usually with large compression folds.


Comparisons. Calamospora liquida is char-
characterized by its long laesurae (greater than half the spore radius).

Previous records. This species has a widespread occurrence in Carboniferous strata.

Calamospora cf. C. nigrata (Naumova) Allen, 1965
(Fig. 2 N)

Description. Spores radial, trilete. Amb circular to subcircular. Laesurae simple, one-half to one-third of spore radius in length. Contact areas darkened. Exine laevigate, thin; folding very frequent.

Dimensions. 44-50 µm (5 specimens).

Comparisons. The present specimens are smaller than those described by Naumova (1953).

Previous records. This species was originally described from the Upper Devonian by Naumova (1953) and later recognized in the Tournaisian by Higgs et al. (1988).

Genus Leiotriletes (Loose) Potonié & Kremp, 1954

Type species. Leiotriletes sphaerotriangulus (Loose) Potonié & Kremp, 1955

Leiotriletes sp.
(Fig. 2 B)

Description. Spores radial, trilete. Amb subtriangular with straight sides and rounded apices. Laesurae distinct, simple or with thin lips, extending up to three-quarters of the spore radius. Contact areas occasionally darkened. Exine laevigate, 1 µm in thickness.

Dimensions. 35-56 µm (8 specimens).

Comparisons. The specimens are treated at the generic level, because they are not clearly assignable to any described species.

Genus Punctatisporites Ibrahim emend.
Potonié & Kremp, 1954

Type species. Punctatisporites punctatus (Ibrahim) Ibrahim, 1933.

**Punctatisporites irrasus** Hacquebard, 1957  
(Fig. 2 A)

*Description.* Spores radial, trilete. Amb subcircular. Laesurae distinct, occasionally with raised narrow lips, extending up to three quarters of the spore radius, frequently with dark intertectal areas. Exine laevigate to finely infragranulate, about 1\(\mu\)m thick. Compression folds common, particularly in the equatorial regions.

*Dimensions.* 42-72 \(\mu\)m (12 specimens).

*Previous records.* *Punctatisporites irrasus* is a characteristic Tournaisian species (Hacquebard, 1957; Sullivan, 1964; Clayton *et al*., 1977).

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**Retusotriletes mirabilis** (Neville) Playford, 1978  
(Fig. 2 F)

*Description.* Spores radial, trilete. Amb convexly subtriangular to subcircular and rounded acute apices. Laesurae simple or with narrow lips extending four-fifths of spore radius. Contact areas well defined by perfect curvaturae. Exine laevigate.

*Dimensions.* Equatorial diameter: 48-54 \(\mu\)m (10 specimens).

*Comments.* The specimens are in the lower extreme of the size range of the species.

*Previous records.* This is a characteristic species of the Viséan in Australia and England (Playford, 1991).

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**Infraturma RETUSOTRILETI** Streel, 1974

Genus **Retusotriletes** Naumova *emend.* Streel, 1974

*Type species.* *Retusotriletes simplex* Naumova, 1953; by subsequent designation of Potonié (1958, p. 13).

**Retusotriletes crassus** Clayton *in* Clayton, Johnston, Sevastopulo & Smith, 1980  
(Fig. 2 G)

*Description.* Spores radial, trilete. Amb subcircular to subtriangular. Laesurae simple, about four-fifths of the spore radius in length. The laesurae end in curvaturae perfectae which delimit the contact areas. Large thickened pads are present in the contact areas, separated from each other by radial zones of thin exine along the laesurae. Also thin exine separates the pads from the equatorial margin.

*Dimensions.* Diameter: 50-55 \(\mu\)m (20 specimens).

*Previous records.* This species is recorded from the latest Strunian to the earliest Carboniferous from Europe (Clayton *et al*., 1980).

**Retusotriletes incohatus** Sullivan, 1964  
(Fig. 2 Q)

*Description.* Spores radial, trilete. Amb circular to subcircular. Laesurae distinct, usually extending for three quarters of spore radius, with fine lips. Contact areas depressed, delimited by perfect or imperfect curvaturae. Exine laevigate and darker outside the contact areas. Due to corrosion the specimens seem micropunctate.

*Dimensions.* 43-57 \(\mu\)m (10 specimens).

*Previous records.* This species originally described for the Tournaisian has been widely reported from late Famennian - early Viséan sequences (Clayton *et al*., 1977).

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**Infraturma APICULATI** Bennie & Kidston *emend.* Potonié, 1956

Subinfraturma **NODATI** Dybová & Jachowicz, 1957

Genus **Anapiculatisporites** Potonié & Kremp, 1954

*Type species.* *Anapiculatisporites isselburgensis* Potonié & Kremp, 1954

**Anapiculatisporites concinnus** Playford, 1962  
(Fig. 2 D, E)

*Description.* Spores radial, trilete. Amb subtriangular with rounded apices and convex to straight sides. Laesurae simple, length three-quarters of spore radius. Proximal surface laevigate. Distal surface sculptured with small coni, 1\(\mu\)m high, about 2-3 \(\mu\)m apart. They are characteristically absent at and around equatorial margin, particularly of interradial areas. Exine about 1 \(\mu\)m thick.

*Dimensions.* 27-32 \(\mu\)m (12 specimens).

*Remarks.* Ravn (1991) emended the genus *Spinositriletes* Dybová and Jachowicz and included the species *concinnus*, but we consider more appropriate to maintain this species in the genus *Anapiculatisporites*.

*Previous records.* Mainly Viséan, worldwide (Playford, 1962; Smith & Butterworth, 1967).

Genus **Anaplanisporites** Jansonius, 1962

*Type species.* *Anaplanisporites telephorus* (Klaus) Jansonius, 1962

**Anaplanisporites cf. A. denticulatus** Sullivan, 1964  
(Fig. 2 I)

*Description.* Spores radial, trilete. Amb rounded triangular to subcircular. Laesurae in-
distinct, reaching almost the margin of the spore, simple or with thin lips. Sculpture of pointed cones with broad bases, 1 µm wide and 1 µm high, restricted to the distal and equatorial region, proximal exine laevigate. Cones arranged regularly in a quasi-concentric manner.

**Dimensions.** 29-40 µm (8 specimens).

**Comparisons.** The present specimens differ from the original in having smaller diameter and the sculpture projecting at the equatorial margin. *Anaplanisporites delicatus* Neves and Ioannides, 1974 differs in having curvaturae imperfectae and granae among the sculptural elements.

Genus *Apiculiretusispora* Streel 1964

**Type species.** *Azonotriletes multisetus* Luber, in Luber & Waltz, 1938

*Apiculiretusispora multisetata* (Luber) Butterworth & Spinner, 1967

(Fig. 2 K, O)

**Description.** Spores radial, trilete. Amb circular to subcircular. Laesurae simple or with narrow lips, straight, usually with distinct curvatures. Exine sculptured by spines with broad bases, approximately 1-2 µm high, densely distributed, less prominent in the contact areas.

**Dimensions.** 40-50 µm (30 specimens).

**Comparisons.** *Apiculiretusispora fructicosa* Higgs 1975, differs in being much larger in size and possessing more varied sculpture including coni, pilae and short bacula. *Butterworth & Spinner, 1967* (Fig. 2 K, O)

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**Dimensions.** 40-50 µm (30 specimens).

**Comparisons.** *Apiculiretusispora fructicosa* Higgs 1975, differs in being much larger in size and possessing more varied sculpture including coni, pilae and short bacula. *Butterworth & Spinner, 1967* (Fig. 2 K, O)
Verrucosisporites irregularis Phillips & Clayton, 1980
(Fig. 2 C)

Description. Spores radial, trilete. Amb subcircular. Laesurae simple, straight, length one half of spore radius. Exine sculptured with verrucae 1.5 µm in diameter, subcircular to irregular in plan view. Usually the verrucae are basally fused forming short muri.

Dimensions. 40-45 µm (5 specimens).

Previous records. This species was described from Lower Carboniferous sediments (Phillips & Clayton, 1980; Higgs et al., 1988).

Genus Cymbosporites Allen, 1965
Type species. Cymbosporites magnificus (Mc Gregor) Mc Gregor & Camfield, 1982

Cymbosporites acutus (Kedo) Byvsheva, 1985
(Fig. 3 I)

Basionym. Archaeozonotriletes acutus Kedo, 1963

Description. Spores radial, trilete. Amb subcircular to subtriangular. Laesurae indistinct, straight. Distal and equatorial regions sculptured with prominent wide and bulbous based spines. Elements discrete or fused in short ridges. Exine infragranulate and darker equatorially due to the sculpture. Spacing of sculptural elements variable, from densely to widely spaced; discrete to basally coalescent.

Dimensions. 28-36 µm (25 specimens).

Comparisons. The cavate nature of this specific taxon was suggested by Higgs et al. (2000) who considered the generic assignment to Grandispora made by Byvsheva in 1980 was far more appropriate than her later assignment (Byvsheva, 1985) to the acamerate genus Cymbosporites. Nevertheless, Melo & Loboziak (2003) maintained the proposal of Byvsheva (1985) and illustrated specimens similar to that here illustrated that seem cavate.

Previous records. This species has been recorded from the latest Famennian to Tournaisian in the northern hemisphere and the latest Famennian of Brazil (Melo & Loboziak, 2003).

Genus Prolycospora Turnau, 1978
Type species. Prolycospora claytonii Turnau, 1978

Prolycospora rugulosa (Butterworth & Spinner) Turnau, 1978

(Figs. 3 A, B, E)

Description. Spores radial trilete, amb subtriangular to subcircular, margin finely crenulated. Laesurae simple, extending almost to the equator. Usually three distinct apical papillae are visible in the contact areas. Proximal surface microgranulose or punctate, distal surface finely rugulose. Cingulum tapering, 2-3 µm wide.

Dimensions. 28-36 µm (25 specimens).

Comparisons. The specimens are very similar to the original ones and to those illustrated by Melo & Loboziak (2003) from the Amazon Basin.

Previous records. This species, originally described from the Lower Carboniferous of England, has its first Late Viséan record in the Amazon Basin (Melo & Loboziak, 2003).

Subturma ZONOLAMINATITRILETES Smith & Butterworth, 1967

Infraturma CINGULICAVATI Smith & Butterworth, 1967

Genus Bascaudaspora Owens, 1983
Type species. Bascaudaspora canipa Owens, 1983.

**Bascaudaspore submarginata** (Playford) Higgs *et al.*, 1988
(Fig. 3 G)

**Description.** Spores radial, trilete, cavate. Amb subtriangular with convex sides and rounded apices. Laesurae indistinct, straight, extending almost to equator with narrow lips. Distal surface reticulate to rugulate with low, smooth, sinuous muri which anastomose or terminate freely. Lumina are usually irregular in shape and size. Muri commonly beaded in appearance due to the presence of small rounded nodes. A distinct and continuous cingulum is present in equatorial region which appears darker and thicker. Proximal surface laevigate. Intexine thin, smooth, barely discernible, three quarters or more of the spore diameter.

**Dimensions.** 40-45 µm (7 specimens).

**Comparisons.** Owens (1983) defined *Bascaudaspore* as an acamerate spore, but its type species, *B. canipa* was described with separation of the exine layers. In accord to Higgs *et al.* (1988) is here considered that the genus accommodates variably camerate/acamerate spores. *B. submarginata* is characterized by a reticulate to rugulate distal surface, formed by narrow smooth sinuous muri and by a dark equatorial cingulum. The present specimens are slightly smaller than the original described by Playford (1964) but they are very similar to those described by Van der Zwan (1980, plate 29, figs. 1-3) as *Dictyotriletes* sp. A, considered a transitional form of his *Dictyotriletes submarginatus* morphon.

**Previous records.** This is a characteristic Strunian-Tournaisian species.

Genus *Cristatisporites* Potonié and Kremp *emend.* Butterworth *et al.*, 1964

**Type species:** *Cristatisporites indignabundus* (Loose) Potonié & Kremp, 1954.

**Cristatisporites sp.**
(Fig. 3 M)

**Description.** Spores radial trilete, cavate. Amb convexly subtriangular, cingulizone, margin conspicuously dentate. Exine bilayered, cavate. Intexine barely distinctive. Zona one-fourth of the spore radius. Proximal surface with reduced sculpture. Laesurae straight with fine lips, extending to the body margin. Distal surface sculptured with coni, verrucae 2-3µm in basal width and 2 µm high, sometimes basally coalescent. Zona sculptured by coni and spines up to 3 µm high with broad bases, discrete or basally coalescent to form cristae.

**Dimensions.** 48-54 µm (5 specimens).

**Comparisons.** The scarce number of well-preserved specimens prevents a close comparison with known species of this genus, characterized by a great variability between representatives of the same species.

Genus *Densosporites* Berry *emend.* Butterworth, Jansonius, Smith & Staplin, 1964
Type species. *Densosporites covensis* Berry, 1937

**Densosporites rarispinosus** Playford, 1963
(Fig. 3 F)

**Description.** Spores radial, trilete. Amb subtriangular, with convex sides. Laesurae occasionally indistinct, straight, extending on to the cingulum, simple or with thin lips. Cingulum 5-10 µm wide, darker in colour than body. Distal surface sculptured with sparsely distributed spines about 2 µm high and subordinate small verrucae. Apart of this sculpture, exine infrapunctate or laevigate.

**Dimensions.** 35-47 µm (10 specimens).

**Comparisons.** Original specimens described by Playford (1963) differ only in having spines up to 6 µm.

**Previous records.** This species was originally described by Playford (1963) from the Lower Carboniferous of Spitsbergen.

Genus *Indotriradites* Tiwari *emend.* Foster, 1979

**Type species.** *Indotriradites korbaensis* Tiwari, 1964

**Indotriradites dolianitii** (Daemon) Loboziak, Melo, Playford & Streel, 1999
(Fig. 3 O)

**Description.** Spores radial, trilete, cavate. Amb subtriangular, convex sides, equatorial margin irregular. Laesurae extending to inner margin of zona, rays with narrow lips. Zona of more or less uniform width (8-10µm), with the inner margin darker. Distal surface more densely sculptured in the central area with bulbous-based elements bearing short spinae, usually basally coalescent. Inner margin of the zona with larger coni and spinae and the rest of the zona with scarce coni and spinae. Intexine distinct, laevigate, thin, slightly contracted from exoexine.

**Dimensions.** Equatorial diameter: 50-70µm (20 specimens).

**Previous records.** *Indotriradites dolianitii* is commonly restricted to the Lower Carboniferous. This species was recognized in the late Viséan
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Faro and Poti Formations in northern Brazil (Dae-

**Indotriradites daemonii** Loboziak, Melo, Playford & Streel, 1999
(Fig. 3 J)

*Description.* Spores radial, trilete, cavate. Amb subtriangular, convex sides, equatorial margin usually undulose. Laesurae extending to inner margin of zona, occasionally with thin lips. Zona of more or less uniform width, with the inner margin darker. Distal surface sculptured with minute coni and spinae. Inner margin of the zona with larger coni and spinae. Intexine distinct, laevigate, thin.

*Dimensions.* Equatorial diameter: 50-60 µm (10 specimens).

*Previous records.* Specimens of *I. daemonii* have been recorded from Viséan strata of North Africa and Brazil (Lanzoni & Magloire, 1969; Ravn et al., 1994, Loboziak et al., 1999).

Genus **Vallatisporites** Hacquebard, 1957

*Type species.* Vallatisporites vallatus Hacquebard, 1957

**Vallatisporites splendens** Staplin & Jansonius, 1964
(Figs. 3 C, D)

*Description.* Spores radial, trilete, cavate. Amb convexly triangular. Laesurae indistinct with narrow lips reaching the equatorial margin. Exine two-layered, cavate. Intexine laevigate, its outline in polar view conformable with the amb. Zona one-fifth of total spore radius in width, with little or no equatorial thinning. Inner part of the zone, with uniserial row of internal vacuoles, delimiting equator of intexinal body as a light area. Sometimes, a slight thickening of the inner half of the remainder zona gives a bizonate appearance. Exoexine proximally laevigate, distally bearing galeae and verrucae 2 µm wide and 2 µm high, irregularly arranged and usually fused in irregular ridges and pads bearing scattered minute coni. Exine thickened equatorially (3-4 µm) and sculptured with discrete coni about 1 µm high and rounded bases.

*Dimensions.* Equatorial diameter: 36-45 µm (10 specimens).

*Comparisons.* The specimens are slightly smaller than the usually described for the species. *Lophotriletes coniferus* Hughes & Playford 1961 also resembles our specimens, but as suggested by Sullivan & Marshall (1966), this species could be synonymous with *C. maculosa*.

*Previous records.* This species is known widely in Late Tournaisian to Namurian assemblages (Sullivan, 1964; Clayton et al., 1977).

**Crassispora** sp.
(Fig. 3 P)

*Description.* Spores radial, trilete. Amb subcircular to convexly subtriangular. Laesurae distinct, usually accompanied by well developed folds, length up to three quarter of spore radius. Exine thickened equatorially (3-4 µm) and sculptured with discrete coni about 1 µm high and rounded bases.

*Dimensions.* Equatorial diameter: 56-60 µm (15 specimens).

*Comparisons.* The specimens studied here differ from the known species of the genus in the very fine and dense distal sculpture.

Suprasubturma **PSEUDOSACCI** TRILETES
Richardson, 1965

Infraturma **MONOPSEUDOSACCI** Smith & Butterworth, 1957

**Genus Auroraspora** Hoffmeister, Staplin & Malloy, 1955
*Infraturma* CRASSITI Bharadwaj & Venkatachala emend. Smith & Butterworth, 1967

**Genus Crassispora** Bharadwaj emend.
Sullivan, 1964

*Type species.* Crassispora kosankei Potonié & Kremp emend. Bharadwaj, 1957

**Crassispora maculosa** (Knox) Sullivan, 1964
(Fig. 3 N)

*Description.* Spores radial, trilete. Amb subcircular to convexly subtriangular. Laesurae indistinct, usually accompanied by well developed folds, length up to three quarter of spore radius. Exine thickened equatorially (3-4 µm) and sculptured with discrete coni about 1 µm high and rounded bases.

*Dimensions.* Equatorial diameter: 60-64 µm (10 specimens).

*Comparisons.* The specimens are slightly smaller than the usually described for the species. *Lophotriletes coniferus* Hughes & Playford 1961 also resembles our specimens, but as suggested by Sullivan & Marshall (1966), this species could be synonymous with *C. maculosa*.

*Previous records.* This species is known widely in Late Tournaisian to Namurian assemblages (Sullivan, 1964; Clayton et al., 1977).
Type species. *Auroraspora solisortus* Hoffmeister, Staplin & Malloy, 1955

*Auroraspora solisorta* Hoffmeister, Staplin & Malloy, 1955 (Fig. 3 R)

Description. Trilete cavate spores. Amb subcircular to convexly subtriangular. Laesurae simple, usually open, extending to the edge of the intine. Intine body distinct, outline conformable with amb, with a radius approximately one half of that of the exoexine. Exoexine microgranulate to micropunctate, thin, usually with radial folds.

Dimensions. 50-77 µm (20 specimens).

Remarks. The described specimens have granulate exoexine as well as the original specimens described by Hoffmeister et al. (1955). *A. macra* Sullivan 1968 is very similar but has a more subtriangular amb with a ratio of diameter of inner body to total spore diameter about three quarters (Van der Zwan, 1980).


*Auroraspora macra* Sullivan, 1968 (Fig. 3 H)

Description. Spores radial, trilete, cavate. Amb subcircular. Ratio of diameter inner body to total spore diameter about 9/10. Laesurae distinct, simple or labrate, extending up to three quarters of the spore radius. Intine laevigate, thin. Exoexine with spongeous infrastructure, frequently sculptured with small granae and folded.

Dimensions. Equatorial diameter: 50-64 µm (10 specimens).

Previous records. This species is characteristic of Tournaisian-Westphalian B of the northern hemisphere assemblages. It also occurs in late Tournaisian and late Viséan palynofloras of northern Brazilian basins (Melo & Loboziaik, 2003).

Genus *Discernisporites* Neves emend. Neves & Owens, 1966

*Discernisporites micromanifestus* (Hacquebard) Sabry & Neves, 1971 (Fig. 2 J)

Description. Spores radial, trilete, cavate. Amb convexly triangular. Laesurae distinct, with narrow lips extending to the margin of the spore; apical papillae occasionally present in the intertectal areas. Intine distinct, laevigate, outline conformable with the amb, diameter approximately four fifths of the miospore diameter. Exoexine thin, finely granulate.

Dimensions. 50-60 µm (5 specimens).

Previous records. *Discernisporites micromanifestus* is known widely in assemblages of the Late Devonian-Namurian interval (Playford, 1991).

Genus *Endosporites* Wilson & Coe ex Schopf, Wilson & Bentall, 1944

*Endosporites sp.* (Fig. 2 R)

Description. Spores radial, trilete, cavate. Amb subcircular to oval. Laesurae distinct, simple, extending up to three quarters of the intinal body radius. Intinal body distinct, laevigate, subcircular, eccentric, approximately one half of the miospore diameter. Exoexine thin, laevigate to infrapunctate, usually folded.

Dimensions. 67-80 µm (5 specimens).

Comparisons. The specimens resemble *Diducites poljessicus* (Kedo) emend. Van Veen, 1981 but do not have the two-layered exoexine.

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

*Grandispora spiculifera* Playford, 1976

(Fig. 3 L)

*Description.* Spores radial, trilete, cavate. Amb circular to subcircular. Laesurae distinct, simple or with slight thickening extending up to intexinal margin. Exoexine with fine, dense, spinose sculpture reduced on the contact areas. Sculptural elements discrete, 1\(\mu\)m long and lesser than 1\(\mu\)m in basal diameter. Intexine distinct, outline more or less conformable with amb.

*Dimensions.* Equatorial diameter: 48-52 \(\mu\)m (15 specimens)

*Previous records.* This species named an Early Carboniferous (Tournaisian) Assemblage palynozone in northwestern Australia (Playford, 1985). Also, *G. spiculifera* characterizes latest Devonian- late Viséan associations from the Amazon Basin (Melo & Loboziak, 2003),

Genus *Spelaeotriletes* Neves & Owens, 1966

*Type species.* *Spelaeotriletes triangulus* Neves & Owens, 1966

*Spelaeotriletes pretiosus* (Playford) Utting, 1987

(Fig. 4 A)

*Description.* Spores radial, trilete, cavate. Amb subtriangular with rounded apices and convex to straight sides. Inner body poorly to well defined, almost parallel to amb outline. Laesurae extending almost to the margin of intexine. Distal sculpture consisting mainly of verrucae with subordinate grana and coni. Verrucae low,
rounded, sometimes bearing single minute coni or spinae; usually discrete but locally fused. Irregular secondary folds common.

Dimensions. 80-94 µm (10 specimens).

Previous records. This species has been recorded from Lower Carboniferous sequences of the northern hemisphere and Northern and Western Gondwana (see Playford et al., 2001, Melo & Loboziak, 2003).

Spelaeotriletes colombianus Dueñas & Césari sp. nov.
(Figs. 4 B-E)

Synonymy. Spelaeotriletes sp., Dueñas & Césari 2006, pl. II, fig. 16

Holotype. 2040-2070 (1) C40/2, Fig. 3 B.

Type locality. SM-2 well, Los Llanos Orientales Basin, Colombia.

Diagnosis. Spores radial, trilette, cavite, with convexly subtriangular amb. Laeisurae almost straight, usually distinct, with narrow lips or exinal folds that extend to equator. Exoexine slightly thickened at the equatorial margin, laevigate on the contact faces and sculptured on distal and equatorial areas. Sculpture of densely distributed small galeae, coni and grana 1-2 µm broad at base, 1-2 µm high; elements usually discrete or connected basally to form short, irregular narrow ridges. Intexine laevigate, forming a distinct mesospore usually 50% of the total diameter, with outline in polar view normally conformable with the amb.

Dimensions. 85-103 µm (20 specimens).

Comparisons. According to the detailed revision of Playford et al. (2001) of some different species of Spelaeotriletes our specimens are distinguishable from the Spelaeotriletes triangulus/Spelaeotriletes arenaceus complex by having diminute, mostly apiculate sculpture of galeae, grana and coni usually discrete, and a slightly thicker exine at the equatorial margin forming a characteristically narrow dark area. According to Playford et al. (2001) and Neves & Owens (1966), S. triangulus Neves & Owens displays distal verrucae, coni and galeae, up to 4 µm broad and 3.5 µm high, regularly distributed and closed spaced that may constitute a reticulum imperfectum. S. arenaceus Neves & Owens is characterized by irregularly distributed verrucae, coni, bacula and pila, up to 2.5 µm broad and 2 µm high. The new species is considered segregated of both, S. triangulus and S. arenaceus type materials, although may be regarded as identical to some Early Carboniferous Amazonian specimens referred to the complex (Melo, pers. comm.). Spelaeotriletes ybertii (Marques Toigo) Playford & Powis emend. Playford et al. 1991, is a distinct form having mostly apiculate sculptural elements like bacula and galeae, usually longer than wide and coalescent in short ridges.

CONCLUSIONS

The palynological assemblages of the SM-4 well, located in the perigondwanic region, provided the only evidence for Early Carboniferous sedimentation in the Colombian Llanos Orientales Basin. The palynofloras contain stratigraphically significant species, including those with Euramerican affinity and those with Gondwanan previous records. As it was pointed out by Dueñas & Césari (in press), the true distribution of the species throughout the sequence is obscured by caving and reworking, but characteristic Viséan species such as Indotriradites morphon, Anapiculatisporites concinnus and Prolycospora rugulosa were identified only above 2250ft. The stratigraphic interval was referred to the Tournaisian-Viséan by Dueñas & Césari (in press). Certainly, future studies in other sequences of the Llanos Orientales Basin will improve the knowledge on the biostratigraphic range of the Colombian assemblages.

ACKNOWLEDGEMENTS

Our thanks to Dr J. H. Melo for his constructive comments as reviewer, to Dr G. Playford by his valuable opinion about some specific identifications and to Dr B. Owens by the reading of an early version of the manuscript. This is a contribution to the IGCP Project 471.

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Recibido: 24-X-2005
Aceptado: 15-XII-2005