



ELSEVIER

Review of Palaeobotany and Palynology 118 (2002) 1–28

**Review of
Palaeobotany
& Palynology**

www.elsevier.com/locate/revpalbo

Late Carboniferous miospores from the Tarma Formation, Pongo de Mainique, Peru

Carlos L. Azcuy^{a,*}, Mercedes di Pasquo^a, Hugo Valdivia Ampuero^b

^a National Research Council of Argentina (CONICET) and Department of Geological Sciences, University of Buenos Aires, Ciudad Universitaria, Pabellón II, 1428 Buenos Aires, Argentina

^b Petroperú S.A. Department of Geology, Paseo de la República, 3361 Lima, Peru

Received 1 December 2000; received in revised form 18 January 2001; accepted 13 August 2001

Abstract

For the first time, a palynologic assemblage is described from the upper section of the Tarma Formation, Peru. It is dominated by monosaccate pollen grains with subordinate striate grains and very few spores. The abundance of *Illinites unicus* has allowed a revision of the systematic position of the form-genus *Illinites*. The assemblage is correlated with the *Illinites unicus* palynozone from the Amazonas Basin, and is considered to be of Westphalian C/Late Atokan age. © 2002 Elsevier Science B.V. All rights reserved.

Keywords: miospores; systematics; Tarma Formation; Late Carboniferous; Argentina

1. Introduction

This contribution forms part of the palynostratigraphic study of outcrops in the Madre de Dios Basin, Peru and northern Bolivia of mainly Carboniferous age. Its aim is to expand the palynologic and stratigraphic knowledge of the relevant formations, to describe their palynomorphs, to establish their ages, to recognize their paleoenvironments and to carry out the comparison and correlation with other microfloras in South America.

The material was obtained from one of the most complete stratigraphic sections exposed in

eastern Peru, located where the Urubamba river leaves the Eastern Range of the Andes to enter the Amazon plains. Here at Pongo de Mainique, the river crosses a 10–15-km dip section through vertical Silurian to Tertiary sedimentary rocks (Text Fig. 1).

Pongo de Mainique is located on the eastern border of the Andean Range, some 450 km east of Lima.

2. Lithostratigraphy

The sedimentary rocks exposed in this region are mainly siliciclastic with minor carbonate components. The latter sequence, mostly Permo-Carboniferous, is divided into four formations (in ascending order): Ambo, Tarma, Copacabana and Ene. The palynomorphs described herein were re-

* Corresponding author.

E-mail address: azcuy@ciudad.com.ar (C.L. Azcuy).

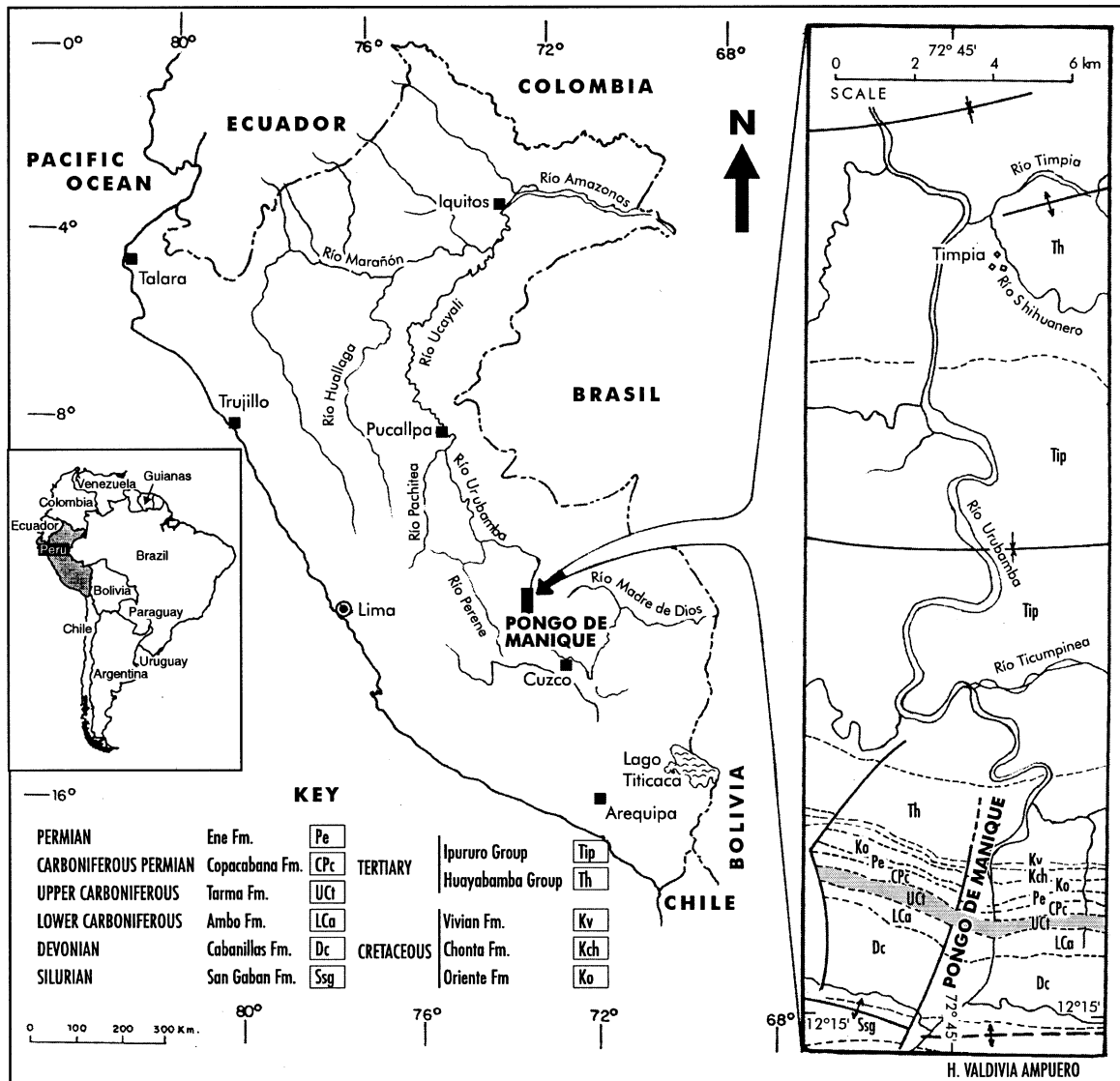


Fig. 1. Location of the Pongo de Mainique locality and distribution of geological units in the area.

covered from the Tarma Formation and are assigned to the Late Carboniferous.

The Tarma Formation, with a thickness of 237 m, rests conformably on the Ambo Formation and is conformably overlain by the Copacabana Formation (Text Fig. 2). The Formation is composed of interbedded light gray micritic limestones that are in part fossiliferous and dolomitic, in beds of varying thickness; thin dark gray marls; light gray siltstones and dark gray to

greenish gray lutites, in medium-sized to thick beds. The basal part of the formation consists of a gray-green to pale gray, medium- to thickly bedded quartzitic sandstone which has a clay or calcareous matrix and is cross bedded.

3. Materials and methods

Only two samples from the Tarma Formation

have yielded abundant recognizable palynologic material (M508 and M509). Both are from the upper part of the unit, close to the boundary with the Copacabana Formation. In both cases the assemblages are well preserved.

Standard methods were used in order to separate palynomorphs (Playford, 1977). The slides have been housed, with sample numbers from the Laboratory of Palynology of Petroperú S.A., in the Laboratory of Palynology, Department of Geology, University of Buenos Aires, Argentina. Palynomorph recognition was made using a Leitz Orthoplan binocular transmitted light microscope No. 871080, with 1000× maximum magnification. The photomicrographs were taken with a Leitz Orthomat camera. Coordinates of specimens are denoted by an England Finder (EF) reference.

4. Systematic palynology

Anteturma Proximegerminantes Potonié 1970
Turma Triletes Reinsch emend. Dettmann 1963
Suprasubturma Acavatitriletes Dettmann 1963
Subturma Azonotriletes Lubert emend. Dettmann 1963
Infraturma Laevigati Bennie and Kidston emend. Potonié 1956

Remarks: Special attention has been paid to previous records of the species here presented, given the scant distribution of some South American records and their usefulness in future biostratigraphic and chronostratigraphic discussions. Bilateral monosaccate and bisaccate pollen grain measurements follow Stephenson and Filatoff's (2000) scheme.

Genus *Calamospora* Schopf, Wilson and Bentall 1944

Type species: *Calamospora hartungiana* Schopf, Wilson and Bentall, 1944.

Botanical affinity: Sphenophyta (Potonié, 1962; Boureau, 1964; Courvoisier and Phillips, 1975). Filicopsida–Pteridophyta (Eggert and Taylor,

1966; Laveine, 1969). Equisetopsida–Progymnospermopsida (Balme, 1995).

Calamospora hartungiana Schopf, Wilson and Bentall 1944 (Plate I, 1)

For synonymy see Césari and Gutiérrez (1984) and Ravn (1986).

Dimensions (5 specimens): Equatorial diameter 87–99.5 µm.

Remarks: Specimens attributed to this species show a thin frequently folded exine, with surface showing weak scabration.

Previous records: Late Carboniferous: South America (Menéndez, 1965; Menéndez and Azcuy, 1969; Césari and Gutiérrez, 1984, 1986; Azcuy, 1975; García and Azcuy, 1987; di Pasquo and Azcuy, 1997, 1999; Playford and Dino, 2000a; Souza, 2000; di Pasquo et al., 2001), Europe (Smith and Butterworth, 1967), USA (Kosanke, 1950; Felix and Burbridge, 1967; Peppers, 1970; Ravn and Fitzgerald, 1982), China (Zhou, 1994). Early Permian: South America (Vergel, 1986a, 1987a,c; Aceñolaza and Vergel 1987; Dias, 1993; Mautino et al., 1998a).

Suprasubturma Pseudosaccitriletes Richardson 1965

Infraturma Monopseudosacciti Smith and Butterworth 1967

Genus *Spelaeotriletes* Neves and Owens 1966

Type species: *Spelaeotriletes triangulus* Neves and Owens, 1966.

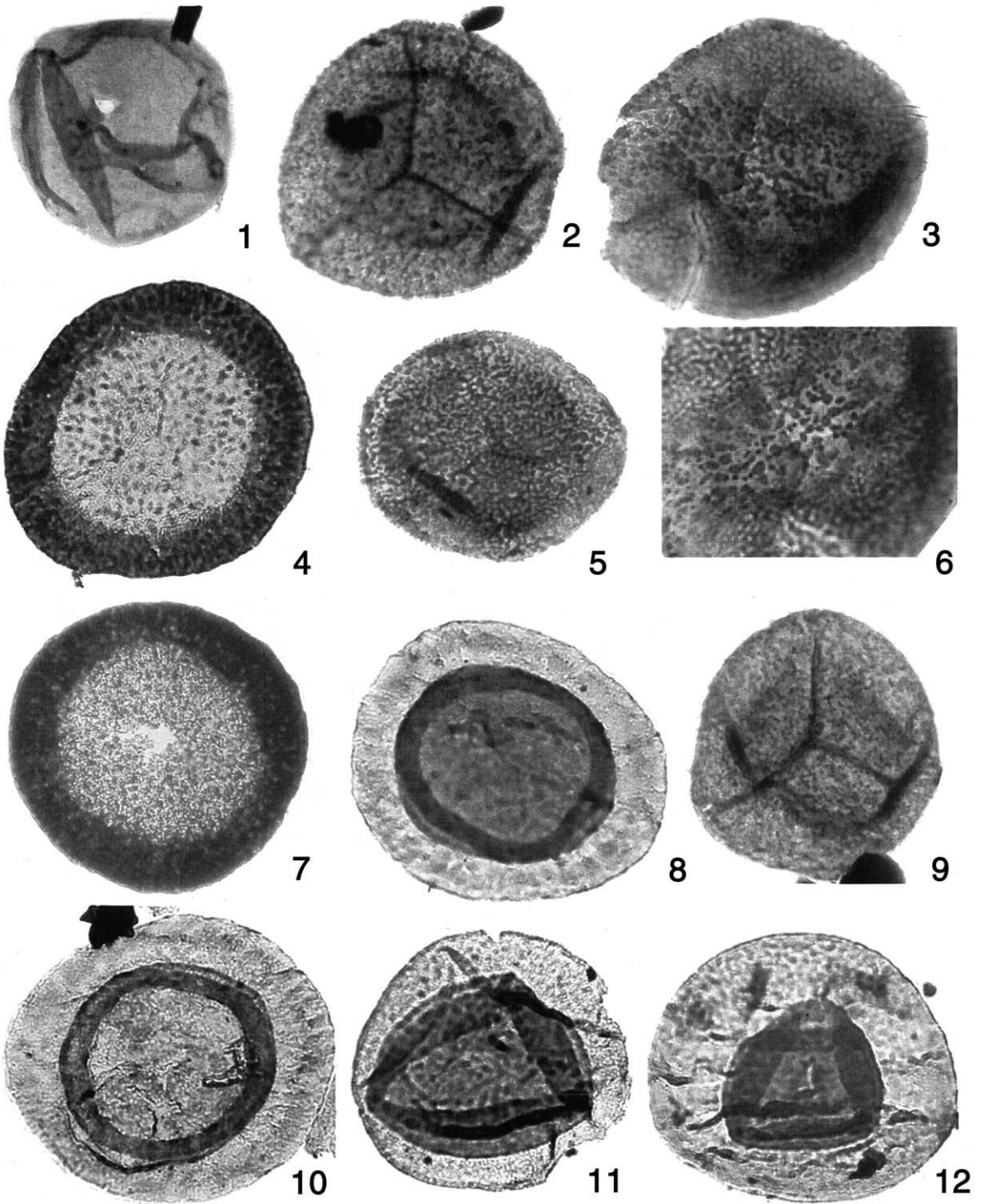
Botanical affinity: Unknown.

Spelaeotriletes ybertii (Marques Toigo) Playford and Powis 1979 (Plate I, 2, 3, 5, 6, 9)

Dimensions (15 specimens): Equatorial diameter 89–118 µm.

Remarks: The Tarma Formation specimens show all the diagnostic characteristics of the species.

Previous records: Late Carboniferous: South America (Lima et al., 1983; Césari, 1985; García and Azcuy, 1987; Ottone, 1989, 1991; Vergel and Luna, 1992; García, 1995; Souza, 2000), Austra-



lia (Playford and Powis, 1979). Early Permian: South America (Marques-Toigo, 1970; Vergel, 1987a,c; Dias, 1993; Césari et al., 1995).

Anteturma Variegerminantes Potonié 1970

Turma Saccites Erdtman 1947

Subturma Monosaccites Chitaley emend. Potonié and Kremp 1954

Infraturma Dipolsacciti Hart emend. Dibner 1971

Remarks: The species of monosaccate pollen grains which are not described here have been extensively discussed by Azcuy and di Pasquo (2000), who have proposed specific identification characters and differences.

Genus *Cannanoropollis* Potonié and Sah 1960

Type species: *Cannanoropollis janakii* Potonié and Sah, 1960.

Botanical affinity: Coniferopsida (Staplin et al., 1967; Potonié, 1967) Ferugliocladales (Archangel'sky and Cúneo, 1987; Balme, 1995).

Cannanoropollis janakii Potonié and Sah 1960 (Plate I, 4, 7)

Dimensions (13 specimens): Equatorial diameter 86 (112) 124 μm .

Previous records: Late Carboniferous–Permian:

South America (Ottone and Azcuy, 1986; Ottone, 1991; Gutierrez, 1993; González et al., 1996; di Pasquo and Azcuy, 1997, 1999; Mautino et al., 1998b; Souza, 2000; di Pasquo et al., 2001), Antarctica (Lindström, 1995), Libya (Loboziak and Clayton, 1988), Oman and Saudi Arabia (Stephenson and Filatoff, 2000). For additional records see Azcuy and di Pasquo (2000) and Playford and Dino (2000b).

Cannanoropollis perfectus (Bose and Maheshwari) Dias Fabrício 1981 (Plate II, 2, 5)

Description: Pollen monosaccate, circular amb, crenulate to undulate margin. Central body distinct, circular to subcircular, without folds. Trilete mark weakly developed. Proximal root equatorial and distal root subequatorial delimiting a circular cappula. Radial folds on saccus conspicuous.

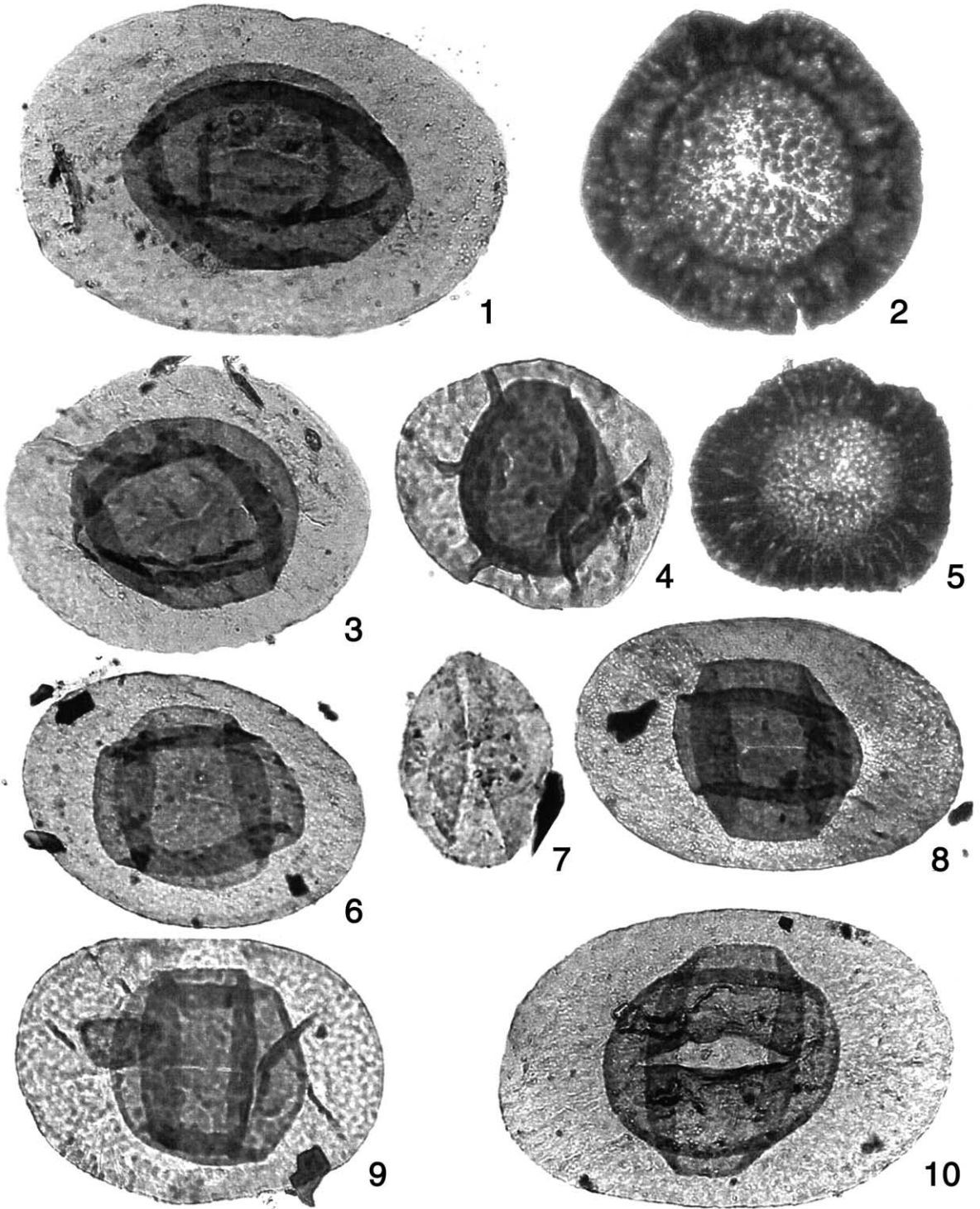
Dimensions (4 specimens): Equatorial diameter 90–98 μm .

Previous records: Late Carboniferous: South America (Souza et al., 1997; Playford and Dino, 2000b; Souza, 2000). Early Permian: South America (Dias Fabrício, 1981; Marques-Toigo, 1988; Dias, 1993; Quadros et al., 1995), Africa (Bose and Maheshwari, 1968; Kar and Bose, 1976).

Genus *Plicatipollenites* Lele 1964

Plate I. Miospores from Tarma Formation assemblages. All $\times 500$ unless otherwise stated.

1. *Calamospora hartungiana* Schopf in Schopf, Wilson and Bentall. BAFC-PI 509: T39.
- 2, 3, 5, 6, 9. *Spelaeotriletes ybertii* (Marques-Toigo) Playford and Powis.
2. BAFC-PI 509: S54.
3. BAFC-PI 509: B56/3.
5. Distal focus, BAFC-PI 509: Q32.
6. Same as 3 with sculptural detail $\times 1000$.
9. BAFC-PI 509: T32/2.
- 4, 7. *Cannanoropollis janakii* Potonié and Sah.
4. BAFC-PI 508: X39.
7. BAFC-PI 508: Q46.
- 8, 10. *Plicatipollenites malabarensis* (Potonié and Sah) Foster.
8. BAFC-PI 509: T44/3.
10. BAFC-PI 509: U60.
- 11, 12. *Potonieisporites triangulatus* Tiwari.
11. BAFC-PI 509: R56/1.
12. BAFC-PI 509: Q43/1.



Type species: Plicatipollenites malabarensis (Potonié and Sah) Foster, 1975.

Botanical affinity: Coniferophyta (Potonié, 1967; Bharadwaj, 1975; Clement-Westerhof, 1984); Cordaitales and/or Coniferales (Vergel, 1986b).

Plicatipollenites malabarensis (Potonié and Sah) Foster 1975 (Plate II, 8, 10)

Dimensions (5 specimens): Equatorial diameter 102–116 µm.

Previous records: Late Carboniferous: South America (Azcuy and Jelín, 1980; Azcuy and Lafitte, 1981; Gutierrez et al., 1983; Limarino et al., 1984; Césari, 1984; Azcuy and Gutiérrez, 1984, 1985; Barreda, 1986; Gutierrez and Césari, 1986; Ottone and Azcuy, 1986, 1989, 1990; Vázquez Nístico and Césari, 1987; García and Azcuy, 1987; Césari and Vázquez Nístico, 1988; Ottone, 1989; di Pasquo and Azcuy, 1997, 1999; Azcuy and di Pasquo, 2000; Playford and Dino, 2000b; Souza, 2000; di Pasquo et al., 2001), Saudi Arabia (Owens et al., 2000). Early Permian: South America (Archangelsky and Gamero, 1979, 1980; Archangelsky et al., 1980; Dias Fabrício, 1981; Vergel, 1987a,b,c; Aceñolaza and Vergel, 1987; Marques-Toigo, 1988; Césari et al., 1995), Libya (Loboziak and Clayton, 1988). For additional records see Azcuy and di Pasquo (2000) and Playford and Dino (2000b).

Genus *Crucisaccites* Lele and Maithy 1964

Type species: Crucisaccites latisulcatus Lele and Maithy, 1964.

Botanical affinity: Gymnospermopsida? Gutierrez (1993).

Crucisaccites monoletus Maithy 1965 (Plate III, 2, 5)

For synonymy see Césari (1984) and Ottone and Azcuy (1989).

Dimensions (3 specimens): Equatorial diameter 104–118 µm.

Remarks: The bilateral orthogonal adherence of the sacci on the proximal and distal faces of the pollen grains in the Peruvian specimens leaves free areas which are wide relative to those of the type material.

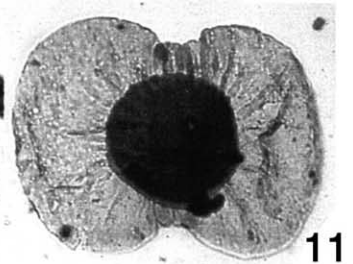
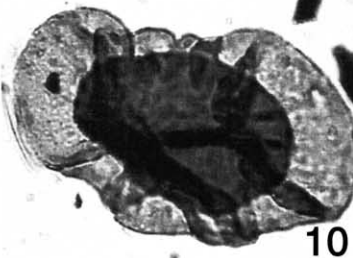
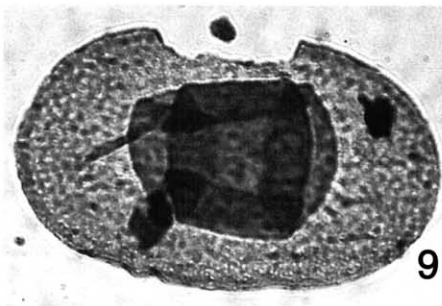
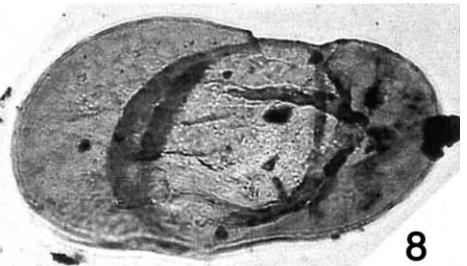
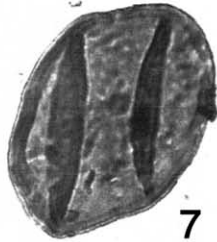
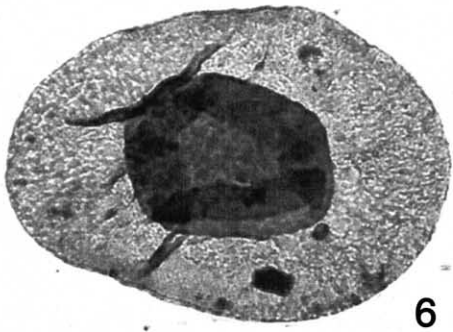
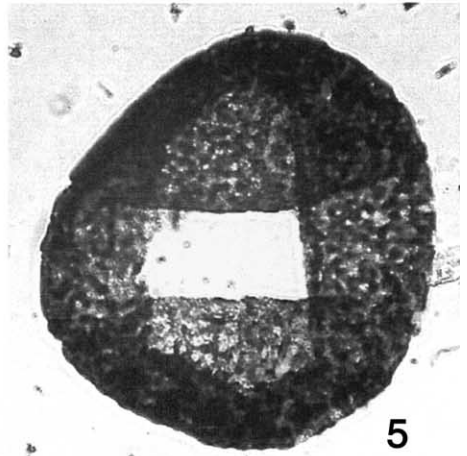
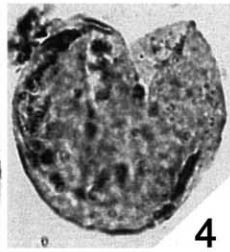
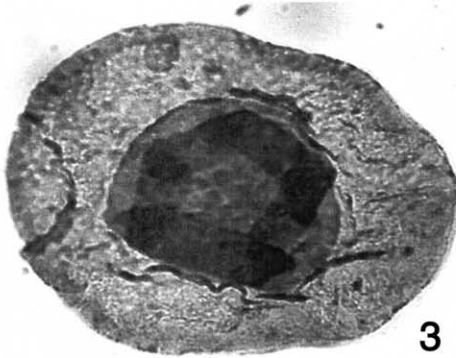
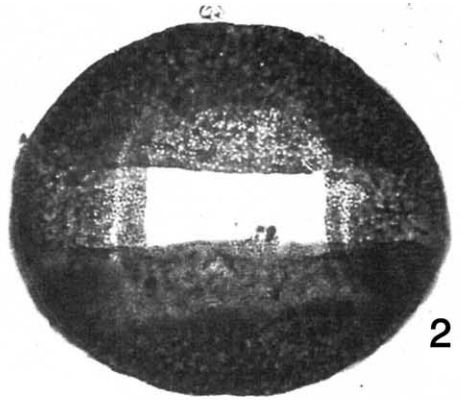
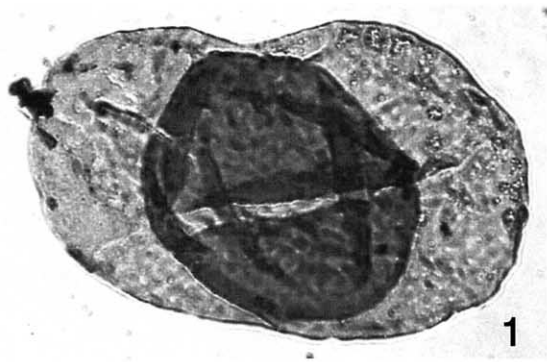
Previous records: Late Carboniferous: South America (Azcuy and Gutiérrez, 1984; Césari, 1984; Ottone and Azcuy, 1986, 1989, 1990; Vázquez Nístico and Césari, 1987; Césari and Vázquez Nístico, 1988; Ottone, 1991; Gutierrez, 1993; García, 1996; di Pasquo and Azcuy, 1999; Souza, 2000; di Pasquo et al., 2001). Early Permian: India (Maithy, 1965; Lele and Maithy, 1969), Australia (Foster, 1979).

Genus *Potonieisporites* Bharadwaj emend. Bharadwaj 1964

Type species: Potonieisporites novicus Bharadwaj, 1954.

Plate II. Miospores from Tarma Formation assemblages. All ×500 unless otherwise stated.

- 1, 3. *Potonieisporites novicus* Bharadwaj emend. Poort and Veld.
1. BAFC-PI 509: W40/1.
3. BAFC-PI 509: V40/3.
- 2, 5. *Cannanoropollis perfectus* (Bose and Maheshwari) Dias Fabrício.
2. BAFC-PI 508: J59.
5. BAFC-PI 508: F56.
4. *Potonieisporites magnus* Lele and Karim BAFC-PI 509: G45/1.
7. *Cycadopites* sp. BAFC-PI 509: O39/1, ×1000.
- 6, 8, 9, 10. *Potonieisporites neglectus* Potonié and Lele.
6. BAFC-PI 509: N42.
8. BAFC-PI 509: P61.
9. BAFC-PI 509: J32/1.
10. BAFC-PI 509: V58.



Botanical affinity: Pteridospermales (Potonié, 1967); Coniferopsida, Voltziales (Bharadwaj, 1964; Staplin et al., 1967; Nygreen and Bourn, 1967; Rothwell, 1982; Taylor, 1982; Clement-Westerhof, 1984; Balme, 1995); Walchiaceae (Poort and Veld, 1997); Coniferales (Vergel, 1986b).

Potonieisporites congoensis Bose and Maheshwari 1968 (Plate III, 9)

For synonymy see Azcuy and di Pasquo (2000).

Dimensions (1 specimen): Longitudinal axis 120 μm , transverse axis 71.2 μm ; longitudinal dimension of corpus 62 μm , transverse axis 47 μm .

Remarks: This species is very rare in the Tarma Formation assemblages.

Previous records: Late Carboniferous: South America (Gutierrez, 1993; di Pasquo and Azcuy, 1997, 1999; Azcuy and di Pasquo, 2000; Souza, 2000; di Pasquo et al., 2001). For additional records see Azcuy and di Pasquo (2000) and Playford and Dino (2000a).

Potonieisporites densus Maheshwari 1967 (Plate III, 3, 6)

1970 *Florinites* sp. Cauduro, pl. XI, 78.

Dimensions (5 specimens): Longitudinal axis 122–139 μm , transverse axis 92.8–110 μm ; longitudinal dimension of corpus 66–70 μm , transverse axis 52.2–73 μm .

Previous records: Late Carboniferous: South America (di Pasquo and Azcuy, 1997, 1999; Souza, 2000; di Pasquo et al., 2001). Early Permian: South America (Cauduro, 1970; Dias, 1993). For additional records see Azcuy and di Pasquo (2000).

Potonieisporites magnus Lele and Karim 1971 (Plate II, 4; Plate IV, 1)

Dimensions (7 specimens): Longitudinal axis 92.7–143 μm , transverse axis 97.4–116 μm ; longitudinal dimension of corpus 46.5–77.7 μm ; transverse axis 62.6–84.6 μm .

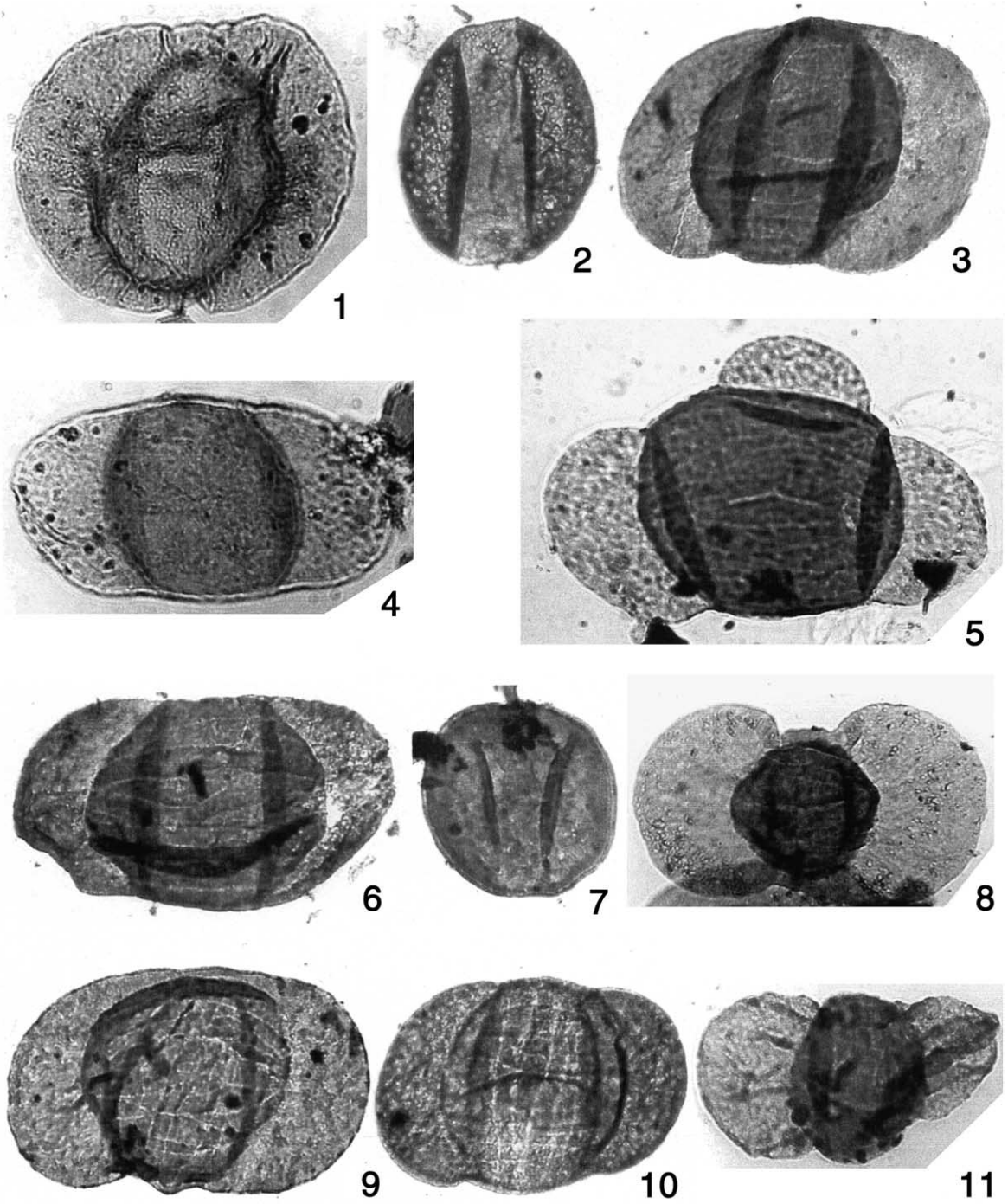
Previous records: Late Carboniferous: South America (Azcuy and Jelín, 1980; Azcuy and Gutiérrez, 1985; García and Azcuy, 1987; Césari and Limarino, 1987; Vázquez Nístico and Césari, 1987; Césari and Vázquez Nístico, 1988; Ottone, 1989, 1991; Ottone and Azcuy, 1989, 1990; García, 1996; di Pasquo and Azcuy, 1997, 1999; Souza, 1997, 2000; Melo et al., 1999; Azcuy and di Pasquo, 2000; di Pasquo et al., 2001). Early Permian: South America (Vergel, 1987a; Césari et al., 1995).

Potonieisporites neglectus Potonié and Lele 1961 (Plate II, 6, 8, 9, 10)

Dimensions (10 specimens): Longitudinal axis 119.5–183 μm , transverse axis 84.5–114 μm ; longitudinal dimension of corpus 58–84.5 μm , transverse axis 59–84.5 μm .

Plate III. Miospores from Tarma Formation assemblages. All $\times 500$ unless otherwise stated.

1. *Limitisporites hexagonalis* Bose and Maheshwari. BAFC-PI 509: F51.
- 2, 5. *Crucisaccites monoletus* Maithy.
2. BAFC-PI 508: H33/4.
5. BAFC-PI 508: M64/3.
- 3, 6. *Potonieisporites densus* Maheshwari.
3. BAFC-PI 509: Q32/2.
6. BAFC-PI 509: J60/4.
4. *Brazilea scissa* (Balme and Hennelly) Foster. BAFC-PI 509: N37/3, $\times 1000$.
7. *Marsupipollenites triradiatus* (Balme and Hennelly) Balme. BAFC-PI 509: M43/4.
8. *Limitisporites rectus* Leschik. BAFC-PI 509: J55/2.
9. *Potonieisporites congoensis* Bose and Maheshwari. BAFC-PI 509: M54.
- 10, 11. *Caheniasaccites flavatus* Bose and Kar emend. Azcuy and di Pasquo.
10. BAFC-PI 509: K53/2.
11. BAFC-PI 509: O51/3.



Previous records: Late Carboniferous: South America (Lima et al., 1983; Césari, 1984; Césari and Vázquez Nístico, 1988; Ottone, 1989, 1991; Ottone and Azcuy, 1989, 1990; Gutierrez, 1993; García, 1996; di Pasquo and Azcuy, 1997, 1999; Azcuy and di Pasquo, 2000; Souza, 2000; di Pasquo et al., 2001), Israel (Horowitz, 1974). Early Permian: South America (Archangelsky and Gamarro, 1979; Marques-Toigo, 1988; Dias, 1993; Césari et al., 1995; Quadros et al., 1995; Ottone et al., 1998).

Potonieisporites novicus Bharadwaj emend. Poort and Veld 1997 (Plate II, 1, 3)

Dimensions (6 specimens): Longitudinal axis 122–158 µm, vertical diameter 98.4–108 µm; longitudinal dimension of corpus 70–91.3 µm, transverse axis 65–70.5 µm.

Previous records: Late Carboniferous: South America (Lima et al., 1983; Gutierrez and Césari, 1986; Ottone, 1989; Ottone and Azcuy, 1989, 1990; Gutierrez, 1993; García, 1996; di Pasquo and Azcuy, 1997, 1999; Azcuy and di Pasquo, 2000; Souza, 2000; di Pasquo et al., 2001). Early Permian: South America (Daemon and Quadros, 1970; Archangelsky and Gamarro, 1979; Vergel, 1987a,b; Marques-Toigo, 1988; Vergel and Luna, 1992; Dias, 1993; Césari et al., 1995; Quadros et al., 1995; Mautino et al., 1998b; Ottone et al., 1998), Antarctica (Lindström, 1995), Oman and Saudi Arabia (Stephenson and Filatoff, 2000).

Potonieisporites triangulatus Tiwari 1965 (Plate I, 11, 12)

Dimensions (3 specimens): Longitudinal axis 98–110 µm, transverse axis 84.5–102 µm; longitudinal dimension of corpus 58–84.5 µm, transverse axis 59–84.5 µm.

Previous records: Late Carboniferous: South America (Ottone and Azcuy, 1989; Ottone, 1991; Gutierrez, 1993; di Pasquo and Azcuy, 1997, 1999; Azcuy and di Pasquo, 2000; Souza, 2000; di Pasquo et al., 2001). Early Permian: South America (Césari et al., 1995; Ottone et al., 1998).

Genus *Caheniasaccites* Bose and Kar 1966

Type species: *Caheniasaccites flavatus* Bose and Kar, 1966.

Botanical affinity: Coniferophyta (Potonié, 1967; Azcuy, 1978); Ferugliocladaea (Archangelsky and Cúneo, 1987; Archangelsky, 1996).

Caheniasaccites flavatus Bose and Kar emend. Azcuy and di Pasquo 2000 (Plate III, 10, 11)

2000 *Caheniasaccites ovatus* Bose and Kar; Stephenson and Filatoff, pl. 2, fig. j.

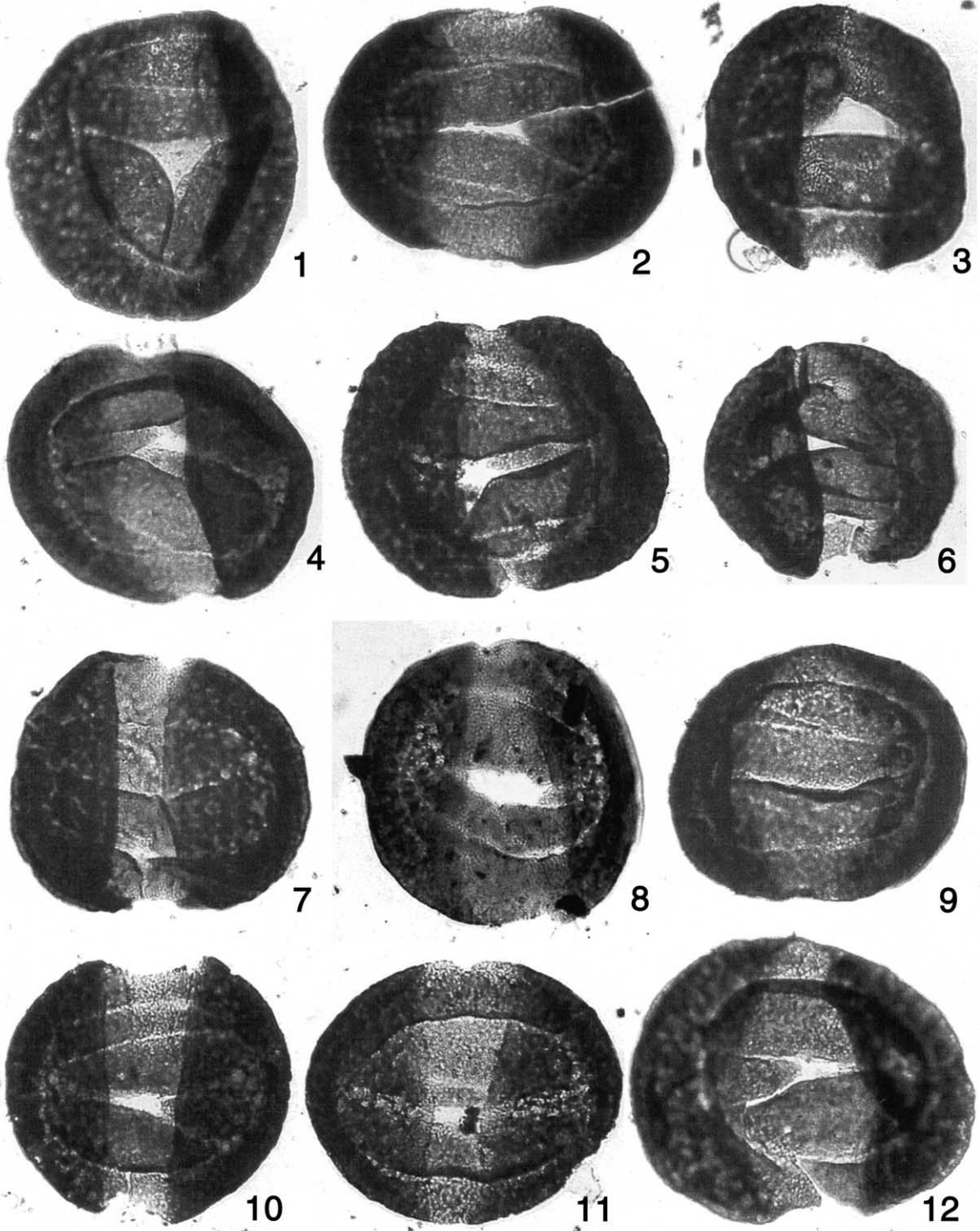
2000a *Caheniasaccites ovatus* Bose and Kar; Playford and Dino, pl. 12, figs. 5–8.

For additional synonymy see Azcuy and di Pasquo (2000).

Dimensions (3 specimens): Longitudinal axis 112.5–170.5 µm.

Plate IV.

1. *Potonieisporites magnus* Lele and Karim. BAFC-PI 509: V59.
- 2, 7. *Marsupipollenites triradiatus* (Balme and Hennelly) Balme.
2. BAFC-PI 509: G45/1.
7. BAFC-PI 509: P33/2.
- 3, 9, 10. *Hamiapollenites insolitus* (Bharadwaj and Saluha) Balme.
3. BAFC-PI 509: H61/2.
9. BAFC-PI 509: J36/2.
10. BAFC-PI 509: U54/2.
4. *Limitisporites rectus* Leschik. BAFC-PI 509: V56/2.
5. *Crustaesporites* sp. BAFC-PI 509: K35/4.
6. *Protohaploxyipinus amplus* (Balme and Hennelly) Hart. BAFC-PI 509: Q33/2.
8. *Sriatopodocarpites fusus* (Balme and Hennelly) Potonié. BAFC-PI 509: R31/2.
11. *Hamiapollenites* sp. BAFC-PI 509: O64/1.



Remarks: In the previous records of this species the specimens under consideration are now considered junior synonyms of *C. flavatus* according to the criteria given by Azcuy and di Pasquo (2000).

Previous records: Late Carboniferous: South America (Césari, 1984; Barreda, 1986; Ottone and Azcuy, 1986; García and Azcuy, 1987; Ottone, 1989; Souza et al., 1997; di Pasquo and Azcuy, 1997, 1999; Azcuy and di Pasquo, 2000; Playford and Dino, 2000a; Souza, 2000; di Pasquo et al., 2001). Early Permian: South America (Marques-Toigo, 1974; Vergel, 1987b,c; Aceñolaza and Vergel, 1987; Beri, 1987, 1988; Beri and Aguilar, 1998), Oman and Saudi Arabia (Stephenson and Filatoff, 2000). For additional records see Azcuy and di Pasquo (2000) and Playford and Dino (2000a).

Subturma *Disaccites* Cookson 1947

Infraturma *Disaccitritei* Leschik emend. Potonié 1958

Genus *Limitisporites* Leschik emend. Schaa-schmidt 1963

For synonymy see Playford and Dino (2000b).

Type species: *Limitisporites rectus* Leschik, 1956.

Botanical affinity: Pteridospermophyta, Glossopteridales (Gould and Delevoryas, 1977). Coniferophyta (Potonié and Schweitzer, 1960;

Grebe and Schweitzer, 1962; Clement-Westerhof, 1984).

Limitisporites hexagonalis Bose and Maheshwari 1968 (Plate III, 1)

Dimensions (4 specimens): Longitudinal axis 132–146 μm ; transverse axis 78–83.5 μm ; longitudinal dimension of corpus 74–81.5 μm .

Previous records: Late Carboniferous: South America (Césari, 1984; Césari and Vázquez Nístico, 1988; Ottone, 1991; Gutierrez, 1993; García, 1996; di Pasquo and Azcuy, 1997, 1999; di Pasquo et al., 2001). Early Permian: South America (Vergel, 1987b; Césari et al., 1995; Ottone and Rossello, 1996; Césari et al., 1996; Mautino et al., 1998b; Ottone et al., 1998).

Limitisporites rectus Leschik 1956 (Plate III, 8; Plate IV, 4)

For synonymy see Foster (1979) and Gutierrez (1993).

Dimensions (4 specimens): Longitudinal axis 122–127 μm ; transverse axis 60.4–65.7 μm ; longitudinal dimension of corpus 64.2–68 μm .

Previous records: Late Carboniferous: South America (Gutierrez, 1993; García, 1996; di Pasquo and Azcuy, 1997, 1999; Azcuy and di Pasquo, 2000; Souza, 2000; di Pasquo et al., 2001). Early Permian: South America (Daemon and

Plate V.

1–12. *Illinites unicus* Kosanke emend. Jansonius and Hills.

1. BAFC-PI 508: H54.
2. BAFC-PI 508: R39.
3. BAFC-PI 508: U40/1.
4. BAFC-PI 508: W45/3.
5. BAFC-PI 508: V46.
6. BAFC-PI 508: T38/3.
7. BAFC-PI 508: F51.
8. BAFC-PI 508: F55/2.
9. BAFC-PI 508: T33/1.
10. BAFC-PI 508: S51/3.
11. BAFC-PI 508: O63/1.
12. BAFC-PI 508: P66/2.

Quadros, 1970; Gamarro and Archangelsky, 1981; Marques-Toigo, 1988; Dias, 1993; Césari et al., 1995; Beri and Daners, 1995, 1998; Césari et al., 1996; Ottone et al., 1998; Beri and Aguilar, 1998), Australia (Segroves, 1969; Foster, 1979; Foster and Waterhouse, 1988; Backhouse, 1991), Antarctica (Lindström, 1995, 1996), Oman and Saudi Arabia (Stephenson and Filatoff, 2000).

Subturma Striatiti Pant 1954

Infraturma Circumstriatiti Lele and Makada 1972

Genus *Illinites* Kosanke 1950 emend.

1956 *Kosankeisporites* Bhardwaj, p. 135.

1962 *Complexisporites* Jizba, p. 878.

1972 *Circumstriatites* Lele and Makada, p. 61.

Type species: Illinites unicus Kosanke emend. Jansonius and Hills 1976 (card 1300).

Botanical affinity: Gymnosperm (Kosanke, 1950; Jizba, 1962; Staplin et al., 1967); Voltziales (Scheuring, 1970). *Ullmannia frumentaria* (Schlottheim) Goepfert (Potonié and Schweitzer, 1960; Grebe and Schweitzer, 1962; Clarke, 1965). ?*Calipteris conferta* Sternberg (Helby, 1966).

Generic remarks: The study of miospores from the Tarma Formation has allowed the recognition of a great number of haploxyloloid bisaccate striated specimens characterized by the presence, on the proximal face of the corpus, of a sub-equatorial furrow that encompasses the taeniae. Taeniae do not cross the furrow to reach the edge of the corpus.

Four genera of striated pollen grains bear these features: *Illinites* Kosanke 1950, *Kosankeisporites* Bhardwaj 1956, *Complexisporites* Jizba 1962 and *Circumstriatites* Lele and Makada 1972. Kosanke (1950) proposed the genus *Illinites* to include species of haploxyloloid non-striated bisaccate specimens, considering them pre-pollen due to the presence of a functional trilete mark. However, he did not recognize the presence of striae contained in a perimetral furrow. *Illinites* was first emended by Potonié and Kremp (1954), who cited Potonié and Klaus (1954) as the authors of the emendation. However, the latter authors did not

provide such an emendation or mention *Illinites* in their work, an error clarified by Klaus (1963). Klaus (1964) proposed an emendation emphasizing the presence of two transverse striae on the cappa, and gave details concerning the arms of the trilete mark but he made no reference to the perimetral furrow.

Helby (1966) discussed the characteristics of the genus in detail, and recognized the presence of 'areas of contact' limited by a perimetral furrow on the cappa. These areas contain additional furrows or striae and a trilete, dilete or monoete mark. Helby (1966), in spite of recognizing the characteristics of a striated grain in *Illinites* and proposing its synonymy with *Kosankeisporites* Bhardwaj, *Complexisporites* Jizba and *Striato-saccites* Jizba (pars), did not emend *Illinites*. The present authors consider that the genus *Striato-saccites* does not present the basic diagnostic features to be included in the synonymy of *Illinites*, as it shows other features of its own, such as transversal striae in the distal face.

Staplin et al. (1967) did not provide a supplemented diagnosis of *Illinites unicus* as mentioned in their summary but instead mentioned the presence of a faint proximal ring-like furrow. Emendation of this species was made by Jansonius and Hills (1976: card 1300), who reviewed the original material and recognized its striated character and the presence of a peripheral furrow of the cappa.

Bhardwaj (1956) created the genus *Kosankeisporites* selecting *Illinites elegans* Kosanke 1950 as the type species, in which he recognized the presence of striae. Peppers (1970) emended the genus and its type species, recognizing the presence of the perimetral furrow. Thus, both *Illinites unicus* and *Kosankeisporites elegans* were shown to have the perimetral furrow containing the striae on the cappa. Jansonius and Hills (1976) proposed *Kosankeisporites* as a junior synonym of *Illinites*. Furthermore, they emended *I. unicus*, type species of the genus, but left the emendation of the genus unresolved. The emendation of *I. elegans* performed by Peppers (1970) is accepted here, but not its combination with the genus *Kosankeisporites*, for the aforementioned reasons.

Complexisporites was created by Jizba (1962) to house species characterized by a perimetral fur-

row on the cappa. Jansonius and Hills (1976; card 540) and Traverse and Ash (1999) consider this genus a junior synonym of *Illinites*. Habib (1966) described *Complexisporites chalonerii*, assigning it to this genus due to the structure of its cappa.

Circumstriatites Lele and Makada 1972 also shows the characteristics of the cappa mentioned above. Lele and Makada (1972) also proposed a new Infraturma to house other taxa with these characteristics in the cappa, defining three species: *Circumstriatites talchirensis*, *Circumstriatites obscurus* and *Circumstriatites ovatus*. Visscher and Brugman (1981) illustrated a specimen (pl. I, fig. 1) which they consider a new species of *Circumstriatites*, anticipating the proposal of a generic emendation.

Features common to all of the species mentioned above are the haploxynoloid character and the presence of a peripheral furrow that contains the taeniae on the cappa. The rest of the features observed such as the shape of the body, the number and characteristics of striae, the shape and inclination of the sacci (width of the cappula), the presence of semilunar folds in the body, and the thickness of the cappa and other minor features, such as size and brochi, represent differences which should be considered as pertaining to the specific level. Therefore, it is proposed to emend the genus *Illinites* to contain the species with the diagnostic features mentioned above, given the fact that Jansonius and Hills (1976) never accomplished a generic emendation. Likewise, we agree with these authors on the synonymy proposed of *Kosankeisporites* and *Complexisporites* to *Illinites*, adding *Circumstriatites* to that list.

Generic diagnosis (emended): Bisaccate pollen grains, striated, haploxynoloid to very slightly diploxynoloid. Corpus of various forms with a laevigate, punctuate or finely granulate exine. Fisured cappa with a more or less peripheral canal (about sub-equatorial in position) containing a variable number of taeniae. In a central position, a furrow is frequently present, as a laesura-like monolete to an imperfect trilete formed by a wider stria which is penetrated by a triangular or wedge-shaped taenia. The attachment of sacci in the distal face may be accompanied by folds. Width of the cappula or sulcus is variable.

Remarks: In the long history of *Illinites* since its creation by Kosanke (1950) and the subsequent discussions started by Potonié and Kremp (1954), Klaus (1963, 1964), Helby (1966), and Scheuring (1970), the debate has been focused on the morphologic characteristics of the trilete mark and its germinative function. This characteristic has always been difficult to establish and so it should not be used as a generic diagnostic feature (Azcuy and di Pasquo, 2000). Beginning with Kosanke's (1950) diagnosis, *Illinites* has been compared with other non-striated genera like *Limitisporites* Leschik and *Jugasporites* Leschik, mainly taking into consideration the characteristics of the proximal opening. Based upon these studies, *Limitisporites* and *Jugasporites* have been synonymized with *Illinites* (Grebe and Schweitzer, 1962; Clarke, 1965), although Klaus (1963), considering the same features, maintained them as separate genera.

The *Illinites* emendation proposed here aims at formally establishing, in agreement with the International Code of Botanical Nomenclature, the true diagnostic features of the genus as shown by its type species. The detailed analysis of the Peruvian material and of the bibliography related to the *Illinites* species and of the genera now placed in synonymy shows a lack of consistency in the discussion concerning laesurae.

Comparisons: Some species of *Lunatisporites* and *Protohaploxypinus* present a slight resemblance to species of *Illinites*. However, the absence in the first two genera of a perimetral furrow containing the striae marks the essential difference between them and *Illinites*.

Species recognized: At present three distinctive species can be recognized within *Illinites*:

Illinites unicus Kosanke emend. Jansonius and Hills 1976

Illinites elegans Kosanke emend. Peppers 1970

Illinites talchirensis (Lele and Makada) comb. nov. (*Basionym:* *Circumstriatites talchirensis* Lele and Makada 1972; *Geophytology*, 2, p. 62, pl. 4, fig. 44)

The following list contains species, earlier included in other genera, that without any doubt

can be synonymized with one of the three recognized species of *Illinites*. The list after that includes specimens that should be assigned to *Illinites*. The third one includes species of which type samples must be evaluated in the light of the aforementioned discussion. The final list contains species that must be placed in other genera because they are non-striated bisaccate pollen grains.

List of junior synonyms of *Illinites* species

1962 *Complexisporites polymorphus* Jizba, p. 879, pl. 121, figs. 1–14.

Remark: We agree with Helby (1966) that this species is a junior synonym of *Illinites unicus* Kosanke emend. Jansonius and Hills 1976.

1966 *Complexisporites chaloneri* Habib 1966, p. 650, pl. 108, fig. 10.

Remark: We agree with Playford and Dino (2000b) that this species is a junior synonym of *Illinites elegans* Kosanke emend. Peppers 1970.

1972 *Circumstriatites obscurus* Lele and Makada 1972; p. 62, pl. 4, figs. 46, 47.

Remark: We consider that this species is a junior synonym of *Illinites unicus* Kosanke emend. Jansonius and Hills 1976.

1972 *Circumstriatites ovatus* Lele and Makada, p. 62, pl. 4, figs. 48, 49.

Remark: We consider that this species is a junior synonym of *Illinites elegans* Kosanke emend. Peppers 1970.

1976 *Protohaploxylinus circumvens* Falcon, p. 29, pl. 4, fig. 11.

Remark: We consider that this species is a junior synonym of *Illinites talchirensis* (Lele and Makada) comb. nov.

Illinites paucitaeniatus (Césari, Archangelsky and Seoane) comb. nov.

1995 *Protohaploxylinus paucitaeniatus* Césari, Archangelsky and Seoane, p. 93, pl. 6, fig. 50.

Remark: We agree with Playford and Dino (2000b) that this species is a junior synonym of *Illinites unicus* Kosanke emend. Jansonius and Hills 1976.

List of specimens to be assigned to *Illinites*

1967 *Kosankeisporites* sp. Staplin, Pocock and Jansonius; pl. 1, fig. 3.

1981 *Circumstriatites* sp. Visscher and Brugman; pl. 1, fig. 1.

1994 *Complexisporites* sp. Zhou; pl. 4, fig. 8.

List of species that must be revised before assignment to *Illinites*

1964 *Kosankeisporites* sp. Neves, pl. 3, figs. 5–8.

1964 *Illinites chitonoides* Klaus, pl. 3, fig. 25.

1964 *Illinites kosankei* Klaus, pl. 3, figs. 23, 24.

1964 *Illinites melanocarpus* Klaus, pl. 3, fig. 29.

1966 *Illinites trivisus* Visscher, pl. 14, fig. 2.

List of taxa that are excluded from *Illinites* because of the lack of striae

1955 *Illinites bentzi* Klaus, pl. 34, fig. 6.

1956 *Illinites purus* Leschik, pl. 21, fig. 6.

1956 *Illinites spectabilis* Leschik, pl. 21, fig. 7.

1956 *Illinites tener* Leschik, pl. 21, fig. 8.

1962 *Illinites delasaucei* (Potonié and Klaus) Grebe and Schweitzer (ibid. Potonié and Klaus, pl. 10, fig. 6).

1963 *Illinites gamsi* Klaus, pl. 5, fig. 16.

1963 *Illinites parvus* Klaus, pl. 5, fig. 18.

1963 *Illinites pemphicus* Klaus, pl. 5, fig. 17.

1965 *Illinites klausi* Clarke, pl. 40, fig. 12, pl. 43, fig. 14.

1965 *Illinites tectus* (Leschik) Clarke, pl. 41, figs. 6, 7.

1966 *Illinites goldi* Helby, pl. 9, figs. 5–9.

1967 ?*Kosankeisporites* sp. Maheshwari, pl. 7, fig. 61.

- 1968 *Illinites* sp. Venkatachala and Kar, pl. 5, fig. 85.
- 1970 *Illinites nitellus* Cauduro, pl. 19, figs. 129–131.
- 1970 *Illinites dissectus* (Hart) Srivastava, p. 163 (combination not accepted here).
- 1970 *Illinites novus* (Tiwari) Srivastava, p. 164 (combination not accepted here).
- 1971 *Illinites notus* Lele and Karim, pl. 2, figs. 20, 21.
- 1987 *Illinites* sp. Vergel, pl. 2, fig. 14.
- 1987 *Illinites* sp. Aceñolaza and Vergel, pl. 1, fig. 10.
- Illinites unicus* Kosanke emend. Jansonius and Hills 1976 (Plate V, 1–12)
- 1962 *Complexisporites polymorphus* Jizba, p. 879, pl. 121, fig. 1–14.
- 1966 *Complexisporites polymorphus* Jizba; Tschudy and Kosanke, pl. 1, fig. 29.
- 1972 *Circumstriatites obscurus* Lele and Makada, p. 62, pl. 4, figs. 46, 47.
- 1976 *Illinites unicus* Kosanke emend. Jansonius and Hills, card 1300.
- 1995 *Complexisporites polymorphus* Jizba; Quardros, Marques-Toigo and Cazzulo-Klepzig, p. 36.
- 1995 *Protohaploxypinus paucitaeniatus* Césari, Archangelsky and Seoane; p. 93, pl. 6, fig. 50.
- 1995 *Protohaploxypinus micros* auct. non Hart 1964; Césari, Archangelsky and Seoane, p. 92, pl. 6, fig. 47.
- 1997 *Complexisporites polymorphus* Jizba; Ghavidel-Syooki, pl. 6, Fig. 1, 12.
- 1999 *Complexisporites polymorphus* Jizba; Traversé and Ash, fig. 3D, E, G.
- 2000 *Complexisporites polymorphus* Jizba; Stephenson and Filatoff, pl. 2, fig. p.

Holotype: Kosanke, 1950, pl. 1, fig. 3.

Type locality: 10-inch coal bed exposed in Coffee Creek, Wabash County, IL, USA; Missourian.

Emended diagnosis (Jansonius and Hills, 1976; transcription card 1300): “Bisaccate pollen; central body thin-walled, elliptical to oval in shape; proximally grooves incised in exoexine over the body, forming internal striae which may bifurcate and connect with a ring groove

that encircles the striate area, with a diameter smaller than the c.b.; sacci only slightly pendant distally, with modest distal overlap, internally finely reticulate to punctate; distal face between sacci thin, without distinct furrow. Size range ca. 55–75 microns”.

Identifying characters: Bisaccate to monosaccate striated pollen grain, haploxytonoid to very slightly diploxytonoid. Corpus distinct to indistinct, circular to subcircular, elongated longitudinal. Cappa multifissured; few striae, sometimes bifurcate; contained in an area that does not exceed the equatorial edge of the corpus, which is limited by a more or less perimetral furrow. The branching of striae occurs principally in the central part of the fissured area. Branching resembles a dehiscence fissure, from irregular trilete to monoete mark. Sacci weakly inclined distally, distal roots define a cappula of variable width and more or less straight edges, occasionally accompanied by folds. The brochi are variable in shape and/or size in different specimens.

Dimensions (38 specimens): Longitudinal axis 90.5–127 μm , transverse axis 81–95 μm ; longitudinal dimension of corpus 86–113 μm ; longitudinal saccus diameter from distal roots 29–47 μm ; longitudinal fissured area of the corpus 64–98 μm , transverse 49–65 μm ; maximum cappula width 23–45 μm ; taeniae width 6–24 μm .

Remarks: The Peruvian specimens of *Illinites unicus* usually show fewer than five striae that define wide taeniae. Most specimens have a deeply forked stria in the central region that resembles an irregular trilete mark. The specimens range from subcircular to oval-shaped, with the corpus covered by narrow sacci faintly inclined distally. The poorly defined distal sacci roots suggest a wide cappula. The range in size of the Peruvian specimens is larger than the one registered in assemblages from USA and Europe. Intermediate sizes were recorded in the Amazonas Basin. This size variability in specimens of *Illinites* should be interpreted as an example of a geographical and chronological morphocline. Henderson and Mei (2000) have discussed a modern example of an extant biotic group with a geographic cline. According to this concept, larger forms present in

higher latitudes should evolve by diminishing their size range as they migrate to lower latitudes. This would occur between the Atokan and Missourian.

Comparisons: *Illinites elegans* Kosanke emend. Peppers 1970 (we do not accept Bhardwaj's combination) is separated from *Illinites unicus* by its vertically elongated corpus and by its relatively narrower cappula. Helby (1966) proposed to synonymize *I. elegans* and *I. unicus*, emphasizing the morphological diversity observed in his material. The authors consider that the diverse specimens of *I. elegans* observed in different regions (Kosanke, 1950; Bhardwaj, 1955; Jizba, 1962; Peppers, 1970; Lele and Makada, 1972) show that the aforementioned differences are enough to keep them separated. *Illinites talchirensis* differs from *I. unicus* in having more numerous striae, a narrower cappula and a more distinct rhomboidal corpus. *I. talchirensis* differs from *I. elegans* by a longitudinal elongated corpus and a greater number of striae.

Previous records: Late Carboniferous: South America (Césari et al., 1995; Quadros et al., 1995; Playford and Dino, 2000a,b), USA (Kosanke, 1950; Jizba, 1962; Traverse and Ash, 1999), Europe (Helby, 1966). Early Permian: South America (Quadros et al., 1995), USA Jizba, 1962; Tschudy and Kosanke, 1966), Europe (Helby, 1966), India (Lele and Makada, 1972), Iran (Ghavidel-Syooki, 1997), Oman and Saudi Arabia (Stephenson and Filatoff, 2000).

Infraturma *Striatiti* Pant 1954

Genus *Protohaploxylinus* Samoilovich emend. Morbey 1975

Type species: *Protohaploxylinus latissimus* (Luber and Valtz) Samoilovich, 1953.

Botanical affinity: Pteridospermophyta–Glossopteridales (Gould and Delevoryas, 1977).

Protohaploxylinus amplus (Balme and Hennelly) Hart 1964 (Plate IV, 6)

For synonymy see Foster (1979).

Dimensions (4 specimens): Longitudinal axis 116–

123 μm , transverse axis 68–79 μm ; longitudinal dimension of corpus 65–81 μm ; longitudinal cappula diameter 30–47.6 μm ; number of striae 7–9.

Remarks: The Tarma Formation specimens are slightly haploxylinoid with a circular to oval corpus showing seven to nine striae and a wide cappula with narrow, scarcely semilunar folds along its border.

Previous records: Late Carboniferous–Early Permian: South America (Daemon and Quadros, 1970; Azcuy and Jelín, 1980; Gutierrez, 1993; Césari et al., 1995; Souza et al., 1997; Mautino et al., 1998a,b), Australia (Foster, 1975; 1979; Rigby and Hekel, 1977), Africa (Anderson, 1977), Antarctica (Lindström, 1995), Oman and Saudi Arabia (Stephenson and Filatoff, 2000). For additional records see Foster (1975).

Genus *Striatopodocarpites* Zoricheva and Sedova ex Sedova emend. Hart 1964

For synonymy see Balme (1970) and Foster (1979).

Type species: *Striatopodocarpites tojmensis* Sedova, 1956.

Botanical affinity: Pteridospermophyta, Glossopteridales (Srivastava, 1970; Lindström et al., 1997).

Striatopodocarpites fusus (Balme and Hennelly) Potonié 1958 (Plate IV, 8)

For synonymy see Segroves (1969) and Foster (1975, 1979).

Description: Pollen bisaccate, taeniate, strongly diploxylinoid. Corpus circular to oval. Cappa with seven to eight subparallel taeniae separated by narrow striae. Sacci exceeding a half-circle in outline and larger than corpus.

Dimensions (1 specimen): Longitudinal axis 112.5 μm , saccus breadth 60.3 μm ; longitudinal dimension of corpus 47.7 μm ; longitudinal cappula diameter 23.2 μm .

Remarks: Except for the greater width of its cappula, the rest of the present specimen's morphological characters are totally coincident with those of *Striatopodocarpites fusus*.

Previous records: It is a very common miospore

assemblage component from Gondwanan Permian microfloras (e.g., South America and other records in Playford and Dino, 2000b; Foster, 1975, 1979).

Genus *Hamiapollenites* Wilson emend. Tschudy and Kosanke 1966

1962 *Distriatites* Bharadwaj, p. 96.

For additional synonymy see Hart (1964), Segroves (1969).

Type species: Hamiapollenites saccatus Wilson, 1962.

Botanical affinity: Coniferophyta (Potonié, 1967; Azcuy, 1978; Quadros et al., 1995).

Remarks: In 1962, the taxa *Hamiapollenites* Wilson and *Distriatites* Bharadwaj were proposed. Later several authors discussed the validity and characteristics of both genera (Hart, 1964, 1965; Playford and Dettmann, 1965; Tschudy and Dwivedi, 1981; among others). The emendation carried out by Tschudy and Kosanke (1966) contributed to facilitate the inclusion in *Hamiapollenites* of forms with a lesser number of distal striae. However, these authors propose that the sacchi be smaller than the width of the corpus, thus leading to the removal from the genus of those forms slightly diploxytonoid up to haploxytonoid with sacchi the same size as the corpus.

No significant differences arise from the consideration of the original diagnoses of both genera to justify the existence of two separate taxa at the generic level. However, Foster (1979) upholds the validity of *Distriatites* emphasizing the size of the sacchi in the zone of adherence, suggesting that they reach or almost reach the transverse axis of the body. Foster also recognizes that the *Hamiapollenites* species, with smaller sacchi, are mainly recorded in the Northern Hemisphere, unlike *Distriatites*, which is recorded in Gondwanan areas.

Bharadwaj and Dwivedi (1981) analyzed the status of both genera, suggesting that *Hamiapollenites* presents exine that is thinner in its distal face, revealing a polysulcate close gap nature. They concluded that *Distriatites* presents only striated distal exine.

The authors consider that the transitional variations in the size of the sacchi in relation to the

width of the corpus shown by some species, including *Hamiapollenites insolitus* (e.g., Playford and Dettmann, 1965; Segroves, 1969), do not justify maintaining two different genera. Likewise, the considerations carried out by Bharadwaj and Dwivedi based on illustrations presented by different authors and Balme's (1970, p. 381) text fig. 8, imply more than a subtle morphological difference, germinative functional differences, the former being very difficult to recognize in fossil material.

Finally, if we add the above considerations to the mention of *Hamiapollenites* by Jansonius (1962, p. 72), *Hamiapollenites* should be senior to *Distriatites*, considering the latter a junior synonym of the former. In this way, the following combination is proposed:

Hamiapollenites bilateris (Bharadwaj) comb. nov.

Basionym: *Distriatites bilateralis* Bharadwaj, 1962; *Palaeobotanist*, 9, p.97, pl. 22, figs. 281, 282.

Hamiapollenites insolitus (Bharadwaj and Salujha) Balme 1970 (Plate IV, 3, 9, 10)

1972 *Distriatites distinctus* Sinha, pl. 8, figs. 107, 108.

1972 *Distriatites indicus* Sinha, pl. 8, figs. 109, 110.

1978 *Hamiapollenites plicatus* Falcon, pl. 4, fig. 6.

1979 *Distriatites insolitus* Bharadwaj and Salujha; Foster, pl. 28, figs. 8, 9.

1981 *Distriatites indicus* Sinha; Bharadwaj and Dwivedi, pl. 8, fig. 86.

1985 *Distriatites insolitus* Bharadwaj and Salujha; Brugman et al., pl. 39, figs. 1, 2, pl. 41, fig. 9.

For additional synonymy see Balme (1970, p. 380), Foster (1979, p. 81).

Remarks: The specimens from Peru are slightly diploxytonoid with a circular corpus to slightly oval in vertical direction; striae are faint on both faces, there are between six and 12 on the proximal face and three to six on the distal face. The cappula is wide and has two narrow, semi-lunar to straight folds on its borders. The presence of folds accompanying the sacchi roots on the

distal face has not been mentioned in the diagnosis (Bharadwaj and Salujha, 1964) or in later original descriptions of the species. This characteristic, however, mentioned in the diagnosis of *Distriatites indicus* Sinha 1972 and *Hamiapollenites plicatus* Falcon 1978 and also illustrated by Brugman et al. (1985, pl. 39, figs. 1 and 2) in specimens assigned to *Distriatites insolitus*, is not considered here a feature of specific value.

Comparisons: *Hamiapollenites bilateris* (Bharadwaj) comb. nov. is distinguished from *Hamiapollenites insolitus* by its greater number of distal striae.

Dimensions (9 specimens): Longitudinal axis 92.8–133 µm, transverse axis 63.8–88 µm; longitudinal dimension of corpus 52–79 µm; longitudinal cappula diameter 25–47.6 µm.

Previous records: Permian: South America (Ottone, 1989; Ottone et al., 1998), India (Bharadwaj and Salujha, 1964; Sinha, 1972; Bharadwaj and Dwivedi, 1981), Pakistan (Balme, 1970), Rhodesia (Falcon, 1978), Australia (Foster, 1979, 1982), Libya (Brugman et al., 1985; Loboziak and Clayton, 1988).

Hamiapollenites sp. (Plate IV, 11)

Description: Pollen bisaccate, taeniate, diploxyloid. Corpus circular to oval longitudinally crossed by eight to nine subparallel taeniae separated by narrow furrows. Distal subsurface of corpus bisected by two to four transverse taeniae. Abundant radially arranged sacchi folds.

Dimensions (1 specimen): Longitudinal axis 99.7 µm, transverse axis 54.5 µm; longitudinal dimension of corpus 44 µm; longitudinal cappula diameter 21 µm.

Remarks: The specimen under study is similar to *Hamiapollenites andiraensis* Playford and Dino 2000b but the apparent lack of a thickening or lengthwise exinal band on its distal face separates it from this species.

Subturma Polysaccites Cookson 1947

Genus *Crustaesporites* Leschik emend. Jansonius 1962

PONGO DE MAINIQUE

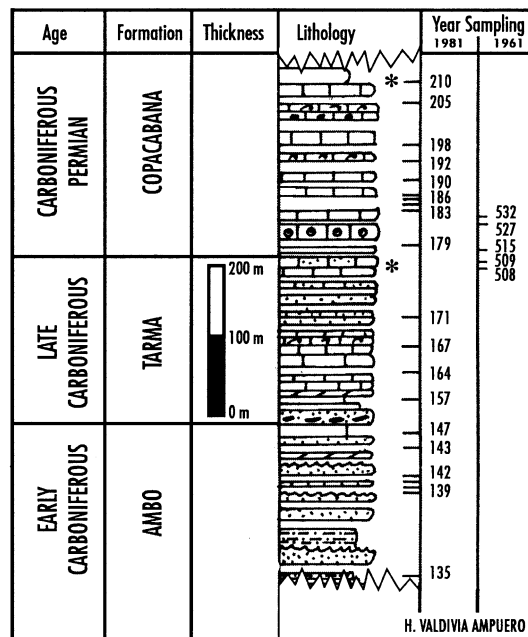


Fig. 2. Composite stratigraphic log of the Tarma Formation showing lithologies and sampling horizons in the Pongo de Mainique section. The asterisks (*) show the sample levels studied (508 and 509) and the one (210) with *Reduviasporites stoschianus* Wood and Elsik (1999).

Type species: *Crustaesporites globosus* Leschik, 1956.

Botanical affinity: Pteridospermaphyta, Glossopteridales (Lindström et al., 1997).

Crustaesporites sp. (Plate IV, 5)

Description: Pollen trisaccate with more or less subtriangular amb. Corpus subpolygonal. Laesurae distinct, slightly geniculate. Proximal sacchi roots equatorial and distally subequatorial associated with three peripheral folds following the amb of the corpus. Cappa with 10–12 narrow striae which are parallel or wedge-shaped; continuous over full breadth of corpus. Sacchi hemispherical. Cappula subpolygonal.

Dimensions (2 specimens): Longitudinal axis 140.3–150.8 µm; longitudinal dimension of corpus 88.5–92.8 µm; longitudinal cappula diameter 48.3–56 µm.

Remarks: No comparable taxon has previously been described in the literature.

Turma Plicates Naumova 1937

Subturma Praecolpates Potonié and Kremp 1954

Genus *Marsupipollenites* Balme and Hennelly emend. Balme 1970

Type species: *Marsupipollenites triradiatus* Balme and Hennelly, 1956.

Botanical affinity: Pteridospermae (Balme and Hennelly, 1956; Balme, 1970).

Marsupipollenites triradiatus (Balme and Hennelly) Balme 1970 (Plate III, 7; Plate IV 2, 7)

Dimensions (3 specimens): Transverse axis 64.5–81 μm .

Previous records: Late Carboniferous–Permian: South America (di Pasquo and Azcuy, 1997, 1999; di Pasquo et al., 2001), Australia (Balme and Hennelly, 1956; Rigby and Hekel, 1977; Foster, 1979), Antarctica (Balme and Playford, 1967), India (Pant and Nautiyal, 1960), Pakistan (Balme, 1970), Oman and Saudi Arabia (Stephenson and Filatoff, 2000).

Subturma Monocolpates Iverson and Troles-Smith 1950

Infraturma Diptyches (Naumova) Potonié 1958

Genus *Cycadopites* Balme and Hennelly emend. Balme 1970

Type species: *Cycadopites triradiatus* Balme and Hennelly, 1956.

Botanical affinity: Pteridospermae (Balme and Hennelly, 1956; Balme, 1970).

Cycadopites sp. cf. *C. adjectus* de Jersey 1962 (Plate II, 7)

Dimensions (1 specimen): Transverse grain diameter 34 μm .

Remarks: The specimen obtained differs from other specimens of *Cycadopites adjectus* in having the colpus somewhat open at the extremities, which are more rounded.

Previous records: Late Carboniferous: South America (di Pasquo and Azcuy, 1997, 1999). Early Permian: India (Tiwari, 1965), Africa (Kar and Bose, 1976).

Group Acritarcha Evitt 1963

Subgroup Schizomorphitae Segroves 1967

Genus *Brazilea* Tiwari and Navale 1967

For synonymy and discussion see Foster (1979).

Type species: *Brazilea punctata* Tiwari and Navale 1967.

Table 1

Distribution of selected species recognized in samples from the Tarma Formation

PREVIOUS RECORDS OF SELECTED MIOSPORES

Species	Late Carb.	Early Perm.
<i>Spelaeotriletes ybertii</i>	=====	=====
<i>Crucisaccites monoletus</i>	=====	=====
<i>Illinites unicus</i>	=====	=====
<i>Cannanoropollis janakii</i>	=====	=====
<i>Cannanoropollis perfectus</i>	=====	=====
<i>Plicatipollenites malabarensis</i>	=====	=====
<i>Potonieisporites congoensis</i>	=====	=====
<i>Potonieisporites densus</i>	=====	=====
<i>Potonieisporites magnus</i>	=====	=====
<i>Potonieisporites neglectus</i>	=====	=====
<i>Potonieisporites novicus</i>	=====	=====
<i>Potonieisporites triangulatus</i>	=====	=====
<i>Caheniasaccites flavatus</i>	=====	=====
<i>Limitisporites hexagonalis</i>	=====	=====
<i>Limitisporites rectus</i>	=====	=====
<i>Protohaploxypinus amplus</i>	=====	=====
<i>Marsupipollenites triradiatus</i>	=====	=====
<i>Hamiapollenites insolitus</i>		=====
<i>Striatopodocarpites fusus</i>		=====

The thinner lines represent fewer previous records.

Brazilea scissa (Balme and Hennelly) Foster 1975 (Plate III, 4)

Dimensions (1 specimens): maximum diameter 31 μm .

Previous records: Late Carboniferous–Early Permian: South America (Burjack, 1978; Archangel-sky and Gamarro, 1979; Vergel, 1987a,b,c; Césari et al., 1995; di Pasquo and Azcuy, 1997, 1999; di Pasquo et al., 2001). Permian: Australia (Balme and Hennelly, 1956; Segroves, 1967; Foster, 1975, 1979), Antarctica (Balme and Playford, 1967; Lindström, 1995), Africa (Hart, 1960, 1963; Bose and Maheshwari, 1968), India (Pant and Nautiyal, 1960), Pakistan (Balme, 1970).

5. Discussion and conclusions

The assemblages from the Tarma Formation were obtained from two samples from the uppermost part of the unit, located immediately below the base of the Copacabana Formation (Text Fig. 2). It is important to remark that the stratigraphic relationship between the Tarma and Copacabana Formations is transitional and conformable which makes the identification of the boundary between them arbitrary. In this study, the samples are located 20 m below the arbitrary boundary between the formations as suggested by one of the authors (H.V.A.). The criterion used to establish the boundary was a fair increasing of mudstones, typical of Copacabana Formation.

The assemblages found in the samples are characterized by few spores, and the fact that species present in one are absent from the other. In sample 508, *Illinites unicus* is the dominant species; also present are *Cannanoropollis janakii*, *Cannanoropollis perfectus* and *Crucisaccites monoletus*. The assemblage in sample 509, located about 10 m stratigraphically above the previous sample, shows a greater diversity; it is dominated by monosaccate pollen (*Plicatipollenites* spp., *Potoniaesporites* spp., *Caheniasaccites* spp.), *Spelaeotriletes ybertii*, *Hamiapollenites insolitus*, and certain taeniate and non-taeniate bisaccate pollen (*Limitisporites* spp., *Protohaploxylinus amplus*, *Striatopodocarpites fusus*, *Crustaesporites* sp.). Taking

both assemblages together, the previous records of their species (Table 1), both in Gondwana and in the Northern Hemisphere, seems to indicate a late to perhaps latest Carboniferous age.

Recently, Wood et al. (1997, 1999) and Wood and Elsik (1999) analyzed palynomorphs and microfossils from the Copacabana Formation at the same section of the Urubamba river (Pongo de Mainique) and from another section on the Camisea river, 90 km to the north-east of the latter location. In the former, at about 250 m stratigraphically above samples 508 and 509, Wood and Elsik (1999) indicated the presence of the fungal spore *Reduviasporonites stoschianus* associated with calcareous microfossils and small foraminifera (*Diplosphaerina inaequalis*, *Earlandia elegans* group, *Endothyra* sp., *Endotiranella?* sp., *Pseudoglomospira* sp. and *Globivalvulina bulloides*) of an 'Early–Middle' Pennsylvanian age. The palynomorph assemblage that is found with *R. stoschianus* does not differ substantially from those described here though a thorough comparison is not possible given that most of the taxa were cited at a generic level only.

Similar assemblages to those of the Tarma Formation were recently described by Playford and Dino (2000a,b) from the Amazonas Basin in Brazil. The authors defined five palynozones for the Late Carboniferous of that basin and their *Illinites unicus* Palynozone could be clearly seen in our samples. *Illinites unicus*, *Cannanoropollis janakii*, *Protohaploxylinus amplus* and similar species of *Spelaeotriletes*, *Crucisaccites* and *Cycadopites* are common elements in both the Brazilian and Peruvian assemblages.

Atokan conodonts and fusulinids recorded in the middle to upper Itaituba Formation of the Amazonas Basin (Lemos, 1992a,b; Altiner and Savini, 1995) have enabled Playford and Dino (2000b) to assign a tentative Westphalian C age to the *Illinites unicus*. The correlation of *Illinites unicus* palynozone with others from Argentina and Gondwanan regions is presented in Playford and Dino (2000b).

The first record of taeniate bisaccate pollen grains is known from the Late Namurian to Early Westphalian (Ravn, 1986; Jones and Truswell, 1992; Zhou, 1993, 1994; Ouyang, 1996). How-

ever, the frequent and diverse presence of these grains occurs in somewhat younger strata (Loboziak et al., 1997). In the Tarma Formation assemblages, species that occur commonly such as *Illinites unicus*, *Hamiapollenites insolitus* and *Marsupipollenites triradiatus* would suggest, taking into account the previous records cited above (Table 1), a younger age, from Late Carboniferous (\cong Late Westphalian) to perhaps the latest Late Carboniferous (\cong Late Stephanian). Nevertheless, foraminifera recorded in the overlying Copacabana Formation of the same outcrop are dated as 'Early–Middle' Pennsylvanian (see above). Therefore, the Peruvian assemblages registered in the upper Tarma Formation are considered to be Late Atokan/Westphalian C or slightly older in age and correlated with *Illinites unicus* palynozone.

This apparent contradiction can be attributed to the different stratigraphic resolutions given by the fossil groups. It is acknowledged that foraminifera and conodonts are more precise stratigraphic indicators than palynomorphs. In consequence, for the assemblage under study the age suggested by the first group mentioned is hereby accepted. In future studies, the traditional chronological value assigned to certain taeniate pollen grains such as *Hamiapollenites insolitus* and *Striatopodocarpites fusus* (early Permian) might be modified based on the age control given by the microfossil groups.

Acknowledgements

The authors gratefully acknowledge the help of Dr. Alejandro Amigo in providing useful comments and language suggestions. We are indebted to the reviewers, Drs. D. McLean and M. Stephenson, for providing helpful suggestions that really improved the final manuscript. Financial support was obtained through two grants from the CONICET (PID 4024/97) and FONCyT (Pict 1864/98).

References

- Aceñolaza, F.G., Vergel, M.M., 1987. Hallazgo del Pérmico superior fosilífero en el Sistema de Famatina. 10th Congr. Geol. Argentino, Bariloche, Actas, 3, pp. 125–129.
- Altiner, D., Savini, R.R., 1995. Pennsylvanian foraminifera and biostratigraphy of the Amazonas and Solimões basins (north Brazil). *Rev. Paléobiol.* 14, 417–453.
- Anderson, J.M., 1977. The biostratigraphy of the Permian and Triassic. Part 3. A review of Gondwana Permian palynology with particular reference to the northern Karoo Basin South Africa. *Mem. Bot. Surv. S. Afr.* 41, 1–133.
- Archangelsky, S., 1996. Aspects of Gondwana paleobotany: gymnosperms of the Paleozoic–Mesozoic transition. *Rev. Palaeobot. Palynol.* 90, 287–302.
- Archangelsky, S., Gamero, J.C., 1979. Palinología del Paleozoico superior en el subsuelo de la Cuenca Chacoparanense, República Argentina. I. Estudio sistemático de los palinomorfos de tres perforaciones de la provincia de Córdoba. *Rev. Esp. Micropaleontol.* 11, 417–478.
- Archangelsky, S., Gamero, J.C., 1980. Palinomorfos pérmicos del subsuelo de la Cuenca Colorado, en la Plataforma del Mar Argentino, Provincia de Buenos Aires. *Bol. Inst. Geoci. Univ. São Paulo* 11, 119–124.
- Archangelsky, S., Cúneo, R., 1987. *Ferugliocladaeae*, a new conifer family from the Permian of Gondwana. *Rev. Palaeobot. Palynol.* 51, 3–30.
- Archangelsky, S., Gamero, J.C., Leguizamón, R.R., 1980. Estudios palinológicos de las perforaciones YCF CO1, CO2, y CO3 (Paleozoico superior) Santiago Temple, provincia de Córdoba. *Proceedings, 2nd Congr. Argentino Paleontol. Bioestratigr. and 1st Congr. Latinoamericano Paleontol.*, Buenos Aires, 1978, Vol. 4, pp. 45–49.
- Azcuy, C.L., 1975. Miosporas del Namuriano y Westfaliano de la comarca Malanzán-Loma Larga, Provincia de la Rioja, Argentina. I. Localización geográfica y geológica de la comarca y descripciones sistemáticas. *Ameghiniana* 12, 1–69.
- Azcuy, C.L., 1978. Posible significado paleoecológico de microfloras gondwánicas del Paleozoico superior, especialmente argentinas. *Ameghiniana* 15, 85–95.
- Azcuy, C.L., Jelín, R., 1980. Las palinozonas del límite Carbónico-Pérmico en la Cuenca Paganzo. *Proceedings, 2nd Congr. Argentino Paleontol. Bioestratigr. and 1st Congr. Latinoamericano Paleontol.*, Buenos Aires, 1978, Vol. 4, pp. 51–67.
- Azcuy, C.L., Laffitte, G., 1981. Palinología de la Cuenca Noroeste Argentina. I. Características de las asociaciones carbónicas: problemas e interpretación. *Proceedings, 8th Congr. Geol. Argentino, San Luis*, Vol. 4, pp. 823–838.
- Azcuy, C.L., Gutiérrez, P.R., 1984. Miosporas seleccionadas de algunas secuencias carbónicas de Argentina. *Proceedings, 3rd Congr. Argentino Paleontol. Bioestratigr.*, Corrientes, Vol. 4, pp. 47–52.
- Azcuy, C.L., Gutiérrez, P.R., 1985. Palinología de sedimentitas Carbónicas de la Cuenca San Rafael. *Ameghiniana* 22, 97–109.
- Azcuy, C.L., di Pasquo, M.M., 2000. Palynology of the Late

- Carboniferous from the Tarija Basin, Argentina: a systematic review of monosaccate pollen genera. *Palaeontographica Abt. B* 253, 107–137.
- Backhouse, J., 1991. Permian palynostratigraphy of the Collie Basin, Western Australia. *Rev. Palaeobot. Palynol.* 67, 237–314.
- Balme, B.E., 1970. Palynology of Permian and Triassic Strata in the Salt Range and Surghar Range, west Pakistan. The University Press of Kansas, Special Publication 4, pp. 306–453.
- Balme, B.E., 1995. Fossil in situ spores and pollen grains: an annotated catalogue. *Rev. Palaeobot. Palynol.* 87, 81–323.
- Balme, B.E., Hennelly, J.P.F., 1956. Monolete, monocolpate and alete sporomorphs from Australian Permian sediments. *Aust. J. Bot.* 4, 54–67.
- Balme, B.E., Playford, G., 1967. Late Permian plant microfossils from the Prince Charles Mountains, Antarctica. *Rev. Micropaléontol.* 10, 179–192.
- Barreda, V.D., 1986. Palinología de la Formación El Trampeadero, Paleozoico superior, Provincia de La Rioja. *Proceedings, 4th Congr. Argentino Paleontol. Bioestratigr., Mendoza*, Vol. 1, pp. 211–219.
- Beri, A., 1987. Estudio preliminar del contenido palinológico de la Perforación 201 (Carbonífero superior/Pérmico inferior) del NE del Uruguay. *Proceedings, 7th Simp. Argentino Paleobot. Palinol., Buenos Aires*, Vol. 1, pp. 33–36.
- Beri, A., 1988. Estudio sistemático del contenido palinológico de una muestra de la Formación Tres Islas (Pérmico Inferior) del Uruguay. *Paula-Coutiana* 3, 27–48.
- Beri, A., Daners, G., 1995. Palinología de la Perforación N.221, Pérmico, R.O. del Uruguay. *Geociencias* 14, 145–160.
- Beri, A., Daners, G., 1998. Estudio palinológico de la perforación 201 (DI.NA.MI.GE.), Pérmico, Uruguay. *Bol. R. Soc. Esp. Hist. Nat. (Sec. Geol.)* 94, 55–64.
- Beri, A., Aguilar, C.G., 1998. Resultados palinológicos y estratigráficos de la Formación San Gregorio (Pérmico Inferior) Uruguay. *Rev. Univ. Guarulhos Geoci.* 3, 108–119.
- Bhardwaj, D.C., 1954. Einige neue Sporengattungen des Saarkarbons. *N. Jahrb. Geol. Paläontol.* 11, 512–525.
- Bhardwaj, D.C., 1955. The spore genera from the Upper Carboniferous coals of the Saar and their value in stratigraphical studies. *Palaeobotanist* 4, 119–149.
- Bhardwaj, D.C., 1956. The spore genera from the Upper Carboniferous coals of the Saar and their value in stratigraphical studies. *Palaeobotanist* 4, 119–149.
- Bharadwaj, D.C., 1962. Miospore genera in the coals of Raniganj Stage (Upper Permian), India. *Palaeobotanist* 9, 68–106.
- Bharadwaj, D.C., 1964. *Potoniopsisporites* Bharadwaj, ihre Morphologie, Systematik und Stratigraphie. *Fortschr. Geol. Rheinland Westfalen* 12, 45–54.
- Bharadwaj, D.C., 1975. Palynology in biostratigraphy and palaeoecology of Indian Lower Gondwana Formations. *Palaeobotanist* 22, 150–157.
- Bharadwaj, D.C., Salujha, S.K., 1964. Sporological study of seam VIII in Raniganj Coalfield, Bihar (India) – Part 1. Description of *spora dispersae*. *Palaeobotanist* 12, 181–215.
- Bharadwaj, D.C., Dwivedi, A., 1981. *Spora dispersae* of the Barakar sediments from South Karanpura Coalfield, Bihar, India. *Palaeobotanist* 27, 21–84.
- Bose, M.N., Maheshwari, H.K., 1968. Palaeozoic *Spora dispersae* from Congo. VII. Coal measures near Lake Tanganyika, South of Albertville. *Ann. Mus. R. Congo Belge Sci. Geol. Sér.* 8 60, 1–116.
- Boureau, E., 1964. *Traité de Paléobotanique*. Tome III, Sphenophyta, Noeggerathiophyta. Masson, Paris, pp. 544.
- Brugman, W.A., Eggink, J.W., Loboziak, S., Visscher, H., 1985. Late Carboniferous–Early Permian (Ghzelian–Artinskian) palynomorphs. *J. Micropalaeontol.* 4, 93–106.
- Burjack, M.I., 1978. Estudo palinológico da jazida carbonífera de Charqueadas Rio Grande do Sul, Brasil. Ph.D. Thesis, Universidade de Goiás, Goiania.
- Cauduro, A.D., 1970. Lower Gondwana miospores from São Sepé outcrop (Rio Grande do Sul, Brasil). *Escola de Geologia, Porto Alegre, Spec. Publ.* 17, pp. 1–34.
- Césari, S.N., 1984. Palinología de la Formación Tupe (Paleozoico superior), Sierra de Maz, Provincia de la Rioja. I. *Ameghiniana* 21, 85–102.
- Césari, S.N., 1985. Palinología de la Formación Tupe (Paleozoico superior), Sierra de Maz, provincia de La Rioja. Parte II. *Ameghiniana* 22, 107–212.
- Césari, S.N., Gutiérrez, P.R., 1984. Microflora de la localidad de Los Mogotes Colorados (Paleozoico superior), provincia de La Rioja, República Argentina. *Bol. Inst. Geoci. Univ. São Paulo* 15, 20–31.
- Césari, S.N., Gutiérrez, P.R., 1986. Revisión taxonómica de algunas esporas del Carbonífero de la Cuenca Paganzo, República Argentina. *Proceedings, 4th Congr. Argentino Paleontol. Bioestratigr., Mendoza*, Vol. 1, pp. 205–210.
- Césari, S.N., Limarino, C.O., 1987. Análisis estratigráfico del perfil de la quebrada de la Cortadera (Carbonífero), Sierra de Maz, La Rioja, Argentina. *Proceedings, 4th Congr. Latinoamericano Paleontol., Bolivia*, Vol. 1, pp. 217–233.
- Césari, S.N., Vázquez Nístico, B., 1988. Palinología de la Formación Guandacol (Carbonífero), provincia de San Juan, República Argentina. *Rev. Esp. Micropaleontol.* 20, 39–58.
- Césari, S.N., Archangelsky, S., Villar de Seoane, L., 1995. Palinología del Paleozoico superior de la perforación Las Mochas, provincia de Santa Fe, Argentina. *Ameghiniana* 32, 73–106.
- Césari, S.N., Meza, J.C., Melchor, R.N., 1996. Primer registro palinológico de la Cuenca Pérmica Oriental (Fm. Yacimiento Los Reyunos), Mendoza, Argentina. *Proceedings, 13th Congr. Geol. Argentino and 3rd Congr. Explor. Hidroc., Buenos Aires*, 1996, Vol. 5, pp. 49–63.
- Clarke, R.F.A., 1965. British Permian saccate and monosulcate miospores. *Palaeontology* 8, 322–354.
- Clement-Westerhof, J.A., 1984. Aspects of Permian paleobotany and palynology. IV The conifer *Ortiseia* Florin from the Val Gardena Formation of the Dolomites and the Vicentinian Alps (Italy) with special references to a revised concept. *Rev. Palaeobot. Palynol.* 41, 51–166.

- Courvoisier, J.M., Phillips, T.L., 1975. Correlation of spores from Pennsylvanian coal-ball fructification with dispersed spores. *Micropaleontology* 21, 45–59.
- Daemon, R.F., Quadros, L.P., 1970. Bioestratigrafia do Neopaleozóico da Bacia do Paraná. *Annals, 24th Congr. Bras. Geol., Soc. Bras. Geol., Brasília*, pp. 259–412.
- Dias Fabrício, M.E., 1981. Palinología da Formação Rio Bonito na área de Gravataí - Morungava, Rio Grande do Sul. *Pesquisas* 14, 69–130.
- Dias, M.E.R., 1993. Palinología do Grupo Itararé na Porção Centro-Sul do Rio Grande do Sul, Permiano da Bacia do Paraná, Brasil. *Pesquisas* 20, 119–131.
- di Pasquo, M.M., Azcuy, C.L., 1997. Palinología del Grupo Mandiyutí, Carbonífero Superior, Cuenca Tarija, Argentina. *Proceedings, 10th Congr. Geol. Chileno, Antofagasta, Vol. 1*, pp. 475–479.
- di Pasquo, M.M., Azcuy, C.L., 1999. Paleocología, paleoclima y correlación de estratos carboníferos en la provincia de Salta sobre la base de palinomorfos. *Proceedings, 14th Congr. Geol. Argentino, Salta, Relatorio, Vol. 1*, pp. 254–260.
- di Pasquo, M.M., Azcuy, C.L., Starck, D., 2001. Palinología de la Formación San Telmo en la Sierra San Antonio, provincia de Salta. *Argentina. Ameghiniana* 38, 85–98.
- Eggert, D.A., Taylor, T.N., 1966. Studies of Paleozoic ferns: on the genus *Tedelea gen. nov.*. *Palaeontographica Abt. B* 118, 52–73.
- Falcon, R.M.S., 1978. New Permian miospores from Rhodesia. *Arnoldia Rhodesia* 8, 1–32.
- Felix, C.J., Burbridge, P.P., 1967. Palynology of the Springer Formation of Southern Oklahoma, USA. *Palaeontology* 10, 349–425.
- Foster, C.B., 1975. Permian plant microfossils from the Blair Athol Coal Measures, Central Queensland, Australia. *Palaeontographica Abt. B* 154, 121–171.
- Foster, C.B., 1979. Permian Plant microfossils of the Blair Athol Coal Measures, Baraleba Coal Measures and Basal Rewan Formation of Queensland. *Geol. Surv. Queensland, Publ. 372, Paleontol. Paper 45*, 244 pp.
- Foster, C., 1982. Spore-pollen assemblages of the Bowen Basin, Queensland (Australia): their relationship to the Permian/Triassic boundary. *Rev. Paleobot. Palynol.* 36, 165–183.
- Foster, C.B., Waterhouse, J.B., 1988. The '*Granulatisporites confluens*' Opper-zone and Early Permian marine faunas from the Grant Formation on the Barbwire Terrace, Canning Basin, Western Australia. *Aust. J. Earth Sci.* 35, 135–157.
- Gamerro, J.C., Archangelsky, S., 1981. Hallazgo de palinomorfos permicos en sedimentitas de la Formación Piedra Shotel, Estancia La Casilda y en la perforación Cañadoón Pastos Blancos (YPF Ch CPB es-1), Chubut, Argentina. *Annals, 2nd Congr. Latinoamericano Paleontol., Porto Alegre*, pp. 169–179.
- García, G.B., 1995. Palinología de la Formación El Imperial, Paleozoico Superior, Cuenca San Rafael, Argentina. Parte I: Esporas. *Ameghiniana* 32, 315–339.
- García, G.B., 1996. Palinología de la Formación El Imperial, Paleozoico Superior, Cuenca San Rafael, República Argentina. Parte II: Granos de Polen, *Incertae Sedis*, Acritarcas. *Ameghiniana* 33, 7–33.
- García, G.B., Azcuy, C.L., 1987. Dos asociaciones palinológicas de la Formación El Imperial, al sur del río Diamante, provincia de Mendoza, República Argentina. *Proceedings, 7th Simp. Argentino Paleobot. Palinol., Buenos Aires*, pp. 59–62.
- Ghavidel-Syooki, M., 1997. Palynostratigraphy and palaeogeography of Early Permian strata in the Zagros Basin, Southeast-southwest Iran. *J. Sci. Islam. Repub. Iran* 8, 243–261.
- González, M.E., Muff, R., Vergel, M., Herbst, R., Fasolo, Z., 1996. Nuevas investigaciones en la sección inferior del Grupo Independencia (Pérmico), Paraguay Oriental. *Geopar, Ministerio de Obras Públicas y Comunicaciones, Vol. 1*, pp. 38–49.
- Gould, R.E., Delevoryas, T., 1977. The biology of *Glossopteris*: Evidence from petrified seed-bearing and pollen-bearing organs. *Archeringa* 1, 387–399.
- Grebe, H., Schweitzer, H.J., 1962. Die *Sporae dispersae* des niederrheinischen Zechsteins. *Fortschr. Geol. Rheinland Westfalen* 12, 201–224.
- Gutierrez, P.R., 1993. Palinología de la Formación Agua Colorada (Carbonífero superior), Sierra de Famatina, provincia de la Rioja, Argentina. I. Granos de polen. *Ameghiniana* 30, 163–212.
- Gutierrez, P.R., Césari, S.N., 1986. Nuevos elementos microfiorísticos de la Formación Jejenes (Carbónico), provincia de San Juan. 1st Jornadas Geol. Precordillera, San Juan, 1985, Vol. 1, pp. 168–173.
- Gutierrez, P.R., Limarino, C.O., Césari, S.N., 1983. Estudio de la mega microflora de la Formación Agua Colorada en su localidad tipo. Abstracts, 5th Simp. Argentino Paleobot. Palinol., La Plata, p. 7.
- Habib, D., 1966. Distribution of spore and pollen assemblages in the Lower Kittanning coal of western Pennsylvania. *Palaeontology* 9, 629–666.
- Hart, G.F., 1960. Microfloral investigation of the Lower Coal Measures (K2); Ketewaka-Mchuchuma Coalfield, Tanganyika. *Bull. Geol. Surv. Tanganyika* 30, 1–18.
- Hart, G.F., 1963. Microflora from the Ketewaka-Mchuchuma Coalfield, Tanganyika. *Bull. Geol. Surv. Tanganyika* 36, 1–27.
- Hart, G.F., 1964. A review of the classification and distribution of the Permian miospore: *Disaccate striatiti*. *Proceedings, 5th Congr. Strat. Geol. Carboniferous, Paris, 1963*, Vol. 3, pp. 1171–1199.
- Hart, G.F., 1965. The Systematics and Distribution of Permian Miospores. *Witwatersrand University Press, Johannesburg*, 252 pp.
- Helby, R., 1966. Sporologische Untersuchungen an der Karbon/Perm Grenze im Pfalzer Bergland. *Fortschr. Geol. Rheinland Westfalen* 13, 645–704.
- Henderson, C.M., Mei, S., 2000. Geographical cline in Per-

- mian Neogondolellids and its role in taxonomy: a brief introduction. *Permophiles* 36, 32–37.
- Horowitz, A., 1974. Palynostratigraphy of the subsurface Carboniferous, Permian and Triassic in Southern Israel. *Geosci. Man* 9, 63–70.
- Jansonius, J., 1962. Palynology of Permian and Triassic sediments, Peace River area, western Canada. *Palaontographica Abt. B* 110, 35–98.
- Jansonius, J., Hills, L.V., 1976. Genera File of Fossil Spores and Pollen. Spec. Publ., Department of Geology, University of Calgary, AB.
- Jizba, K.M., 1962. Late Paleozoic bisaccate pollen from the United States Midcontinent area. *J. Paleontol.* 36, 871–887.
- Jones, M.J., Truswell, E.M., 1992. Late Carboniferous and Early Permian palynostratigraphy of the Joe Joe Group, southern Galilee Basin, Queensland, and implications for Gondwanan stratigraphy. *BRM J. Aust. Geol. Geophys.* 13, 143–185.
- Kar, R.K., Bose, M.N., 1976. Palaeozoic *sporae dispersae* from Zaire (Congo). XII. Assise a couches de houille from Greinerville region. *Ann. Mus. R. Afr. Cent. Sci. Geol. Ser.8* 77, 23–113.
- Klaus, W., 1955. Über die Sporendiagnose des deutschen Zechsteinsalzes un des alpinen Salzgebirges. *Z. Dtsch. Geol. Ges.* 105, 776–788.
- Klaus, W., 1963. Sporen aus dem südalpinen Perm. *Jahrb. Geol. Bundesanst.* 106, 229–363.
- Klaus, W., 1964. Zur sporenstratigraphischen Einstufung von gipsführenden Schichten in Bohrungen. *Erdoel-Z.* 80, 119–132.
- Kosanke, R.M., 1950. Pennsylvanian spores of Illinois and their use in correlation. *Illinois Geol. Surv. Bull.* 74, 128 pp.
- Laveine, J.P., 1969. Quelques Pécoptéridinées houillères à la lumière de la palynologie. *Pollen Spores* 11, 619–688.
- Lele, K.M., Maithy, P.K., 1969. Miospore assemblage of the Garyra Nala beds, South Rewa Gondwana Basin with some remarks on the age of the beds. *Palaeobotanist* 17, 298–309.
- Lele, K.M., Karin, R., 1971. Studies in the Talchir Flora of India. 6. Palynology of the Talchir Boulder Beds in Jayanti Coalfield, Bihar. *Palaeobotanist* 19, 52–69.
- Lele, K.M., Makada, R., 1972. Studies in the Talchir Flora of India. 7. Palynology of the Talchir Formation in the Jayanti Coalfield, Bihar. *Geophytology* 2, 41–73.
- Lemos, V.B., 1992a. Conodontes do Carbonífero das bacias do Amazonas e Solimões; taxonomia. Parte I. *Pesquisas* 19, 75–93.
- Lemos, V.B., 1992b. Conodontes do Carbonífero das bacias do Amazonas e Solimões; taxonomia. Parte II. *Pesquisas* 19, 120–131.
- Leschik, G., 1956. Spores aus den Salzen des Zechsteins von Neuhof (Bei Fulda). *Palaontographica Abt. B* 100, 125–141.
- Lima, M.R., Dino, R., Yokoya, N.S., 1983. Palinologia de concreções calcíferas do Subgrupo Itararé (Neopaleozóico da Bacia do Paraná) da região de Araçoiaba da Serra, Estado de São Paulo. *An. Acad. Brasil. Ci.* 55, 195–208.
- Limarino, C.O., Gutiérrez, P.R., Césari, S.N., 1984. Facies lacustre de la Formación Agua Colorada (Paleozoico superior): aspectos sedimentológicos y contenido paleoflorístico. *Proceedings, 9th Congr. Geol. Argentino, Bariloche, Vol. 5*, pp. 324–341.
- Lindström, S., 1995. Early Late Permian palynostratigraphy and palaeo-biogeography of Vestfjella, Dronning Maud Land, Antarctica. *Rev. Palaeobot. Palynol.* 86, 157–173.
- Lindström, S., 1996. Late Permian Palynology of Fossilryggen, Vestfjella, Dronning Maud Land, Antarctica. *Palynology* 20, 15–48.
- Lindström, S., McLoughlin, S., Drinnan, A.N., 1997. Intra-specific variation of taeniate bisaccate pollen within Permian Glossopterid sporangia, from the Prince Charles Mountains, Antarctica. *Int. J. Plant Sci.* 158, 673–684.
- Loboziak, S., Clayton, G., 1988. The Carboniferous palynostratigraphy of northeast Libya. In: El-Arnauti, A., Owens, B., Thusu, B. (Eds.), *Subsurface Palynostratigraphy of Northeast Libya*. Garyounis University Press, Benghazi, pp. 129–149.
- Loboziak, S., Melo, J.H., Dino, R., Vachard, D., Streel, M., 1997. Earliest taeniate bisaccates from the Amazonas Basin are not older than Westphalian. *Géobios* 30, 467–474.
- Maheshwari, H.K., 1967. Studies in the Glossopteris Flora of India – 29. Miospore assemblage from the Lower Gondwana exposures along Bansloi River in Rajmahal Hills, Bihar. *Palaeobotanist* 15, 258–280.
- Maithy, P.K., 1965. Studies in the Glossopteris flora of India. 27. *Sporae dispersae* from the Karharbari beds, in the Giridih Coalfield. *Palaeobotanist* 13, 291–307.
- Marques-Toigo, M., 1970. *Anabaculites nov. gen.*, a new miospore genus from San Gregorio Formation of Uruguay. *Ameghiniana* 7, 79–82.
- Marques-Toigo, M., 1988. Palinologia, bioestratigrafia y paleoecologia do Neopaleozoico da Bacia do Paraná nos Estados do Rio Grande do Sul e Santa Catarina, Brasil. Ph.D. Thesis, Univ. Fed. Rio Grande Sul, Porto Alegre.
- Mautino, L.R., Anzótegui, L.M., Vergel, M.M., 1998a. Palinologia de la Formación Melo (Pérmico Inferior) en Arroyo Seco, Departamento Rivera, República Oriental del Uruguay. Parte IV: Esporas. *Ameghiniana* 35, 67–80.
- Mautino, L.R., Vergel, M.M., Anzótegui, L.M., 1998b. Palinologia de la Formación Melo (Pérmico Inferior) en Arroyo Seco, Departamento Rivera, Uruguay. Parte V: Granos de polen, acritarcas e *incertae sedis*. *Ameghiniana* 35, 299–314.
- Melo, J.H.G., Loboziak, S., Streel, M., 1999. Latest Devonian to early Late Carboniferous biostratigraphy of northern Brazil: an update. *Bull. Centre Rech. Elf Explor. Prod.* 22, 13–33.
- Menéndez, C.A., 1965. Contenido palinológico en sedimentos con '*Rhacopteris ovata*' (Mc Coy) Walkom de la Sierra de Famatina, La Rioja. *Revista del Museo Argentino de Ciencias Naturales 'B. Rivadavia'*. *Paleontología* 1, 45–80.
- Menéndez, C.A., Azcuy, C.L., 1969. Microflora Carbónica de la localidad de Paganoy, provincia de La Rioja. Parte I. *Ameghiniana* 6, 77–97.
- Neves, R., 1964. The stratigraphic significance of the small spore assemblages of the La Camocha Mine, Gijón, N.

- Spain. Proceedings, 5th Congr. Int. Stratigr. Géol. Carbonifère, Paris, 1963, pp. 1229–1238.
- Nygreen, P.W., Bourn, O.B., 1967. Morphological variation of *Potoniaesporites* in a Late Pennsylvanian florule. Rev. Palaeobot. Palynol. 3, 325–332.
- Ottone, E.G., 1989. Palynoflores de la Formación Santa Máxima, Paleozoique superieur, Republique Argentine. Palaeontographica Abt. B 213, 89–147.
- Ottone, E.G., 1991. Palynologie du Carbonifère Supérieur de la coupe de Mina Esperanza, Bassin Paganzo, Argentine. Rev. Micropaléontol. 34, 118–135.
- Ottone, E.G., Azcuy, C.L., 1986. El perfil de la quebrada La Delfina, provincia de San Juan. Rev. Asoc. Geol. Argent. 41, 124–136.
- Ottone, E.G., Azcuy, C.L., 1989. Datos Palinológicos de la Formación Guandacol (Carbonífero) en la quebrada La Delfina, Provincia de San Juan, Argentina. Ameghiniana 26, 191–208.
- Ottone, E.G., Azcuy, C.L., 1990. Palinología del carbón del Agua Hedionda (Carbonífero). Huaco, provincia de San Juan, Argentina. Ameghiniana 27, 3–18.
- Ottone, E.G., Rossello, E.A., 1996. Palinomorfos Pérmicos de la Formación Puerta, Cordillera Frontal, Argentina. Ameghiniana 33, 453–456.
- Ottone, E.G., Rossello, E.A., Simanuskas, T., Vachard, D., 1998. Palaeontology and biostratigraphy of the late Palaeozoic Copacabana Group at the Angosto del Beu, Bolivia. Ameghiniana 35, 87–96.
- Ouyang, S., 1996. On the first appearance of some gymnosperms and GSPD assemblages in the sub-Angara, Euramerican and Cathaysia provinces. Palaeobotanist 45, 20–32.
- Owens, B., Filatoff, J., Clayton, G., Al-Hajri, S., 2000. Evidence of Mid-Carboniferous miospore assemblages from Central Saudi Arabia. In: Al-Hajri, S., Owens, B. (Eds.), Stratigraphic Palynology of the Palaeozoic of Saudi Arabia. GeoArabia Spec. Publ. 1. Gulf PetroLink, Manama, Bahrain, pp. 154–167.
- Pant, D.D., Nautiyal, D.D., 1960. Some seeds and sporangia of *Glossopteris* Flora from Raniganj Coalfield, India. Palaeontographica Abt. B 107, 1–64.
- Peppers, R.A., 1970. Correlation and palynology of coals in the Carbondale and Spoon Formations (Pennsylvanian) of the Northeastern Part of the Illinois Basin. Illinois State Geol. Surv. Bull. 93, 173 pp.
- Playford, G., 1977. Lower to middle Devonian Acritarchs of the Moose River Basin, Ontario. Geol. Surv. Can. Bull. 279, 1–87.
- Playford, G., Dettmann, M.E., 1965. Rhaeto-Liassic plant microfossils from the Leig Creek Coal Measures, South Australia. Senck. Leth. 46, 27–181.
- Playford, G., Powis, G., 1979. Taxonomy and distribution of some trilete spores in Carboniferous strata of the Canning Basin, western Australia. Pollen Spores 21, 371–394.
- Playford, G., Dino, R., 2000a. Palynostratigraphy of upper Palaeozoic strata (Tapajós Group), Amazonas Basin, Brazil: Part one. Palaeontographica Abt. B 255, 1–46.
- Playford, G., Dino, R., 2000b. Palynostratigraphy of upper Palaeozoic strata (Tapajós Group), Amazonas Basin, Brazil: Part two. Palaeontographica Abt. B 255, 87–145.
- Poort, R.J., Veld, H., 1997. Aspects of Permian palaeobotany and palynology. XVIII. On the morphology and ultrastructure of *Potoniaesporites novicus* (prepollen of Late Carboniferous/Early Permian Walchiaceae). Acta Bot. Neerl. 46, 161–173.
- Potonié, R., 1962. Synopsis der Spores in situ. Die Sporen der fossilen Fruktifikationen (Thallophyta bis Gymnospermo-phyta) im natürlichen System und im Vergleich mit den *Sporae dispersae*. Geol. Jahrb. 52, 1–204.
- Potonié, R., 1967. New phylogenetic facts on fossil spores. Rev. Palaeobot. Palynol. 1, 75–82.
- Potonié, R., Klaus, W., 1954. Einige Sporengattungen des alpinen Salzgebirges. Geol. Jahrb. 68, 517–546.
- Potonié, R., Kremp, G., 1954. Die Gattungen der Paläozoischen *Sporae dispersae* und ihre Stratigraphie. Geol. Jahrb. 69, 111–194.
- Potonié, R., Schweitzer, H.J., 1960. Der Pollen von *Ullmannia frumentaria*. Palaeontographica 34, 27–37.
- Quadros, L.P., Marques-Toigo, M., Klepzig, M.C., 1995. Catálogo de esporos e pólen fósseis do Paleozoico. Bol. Geoci. Petrobrás 9, 1–151.
- Ravn, R.L., 1986. Palynostratigraphy of the lower and middle Pennsylvanian coals of Iowa. Iowa Geol. Surv. Tech. Papers 7, 245 pp.
- Ravn, R.L., Fitzgerald, D.J., 1982. A Morrowan (Upper Carboniferous) miospore flora from eastern Iowa, USA. Palaeontographica Abt. B 183, 108–172.
- Rigby, J.F., Hekel, H., 1977. Palynology of the Permian sequence in the Springsure Anticline, Central Queensland. Geol. Surv. Queensland Publ. 363, Palaeontol. Papers 37, 76 pp.
- Rothwell, G.W., 1982. New interpretations of the earliest Conifers. Rev. Palaeobot. Palynol. 37, 7–28.
- Scheuring, B.W., 1970. Palynologische und palynostratigraphische Untersuchungen des Keupers im Bölchentunnel (Solothurner Jura). Schweiz. Paläontol. Abh. Mém. Suisses Paléontol. 88, 3–119.
- Segroves, K.L., 1967. Cutinized microfossils of probable non vascular origin from the Permian of Western Australia. Micropaleontology 13, 289–305.
- Segroves, K.L., 1969. Saccate plant microfossils from the Permian of Western Australia. Grana Palynol. 9, 174–227.
- Sinha, V., 1972. *Sporae dispersae* from Jhingurdah Seam, Singrauli Coalfield (M.P.), India. Palaeobotanist 19, 175–210.
- Smith, A.H.V., Butterworth, M.A., 1967. Miospores in the Coal Seams of the Carboniferous of Great Britain. Palaeontol. Assoc. Spec. Papers Palaeontol. 1, 324 pp.
- Souza, P.A., 1997. Dados palinológicos do Carbonífero da Bacia do Paraná no Brasil. Rev. Univ. Guarulhos Geoci. 2 ((no. especial)), 43–48.
- Souza, P.A., 2000. Palinobioestratigrafia do Subgrupo Itarare, Carbonífero/Permiano, na porção nordeste da Bacia de Paraná (SP/PR, Brasil). Ph.D. Thesis, Univ. São Paulo, S.P
- Souza, P.A., Saad, A.R., Lima, M.R., 1997. Palinologia dos

- carvões paleozóicos do Estado de São Paulo. II – O carvão de Monte Mor. Rev. IG São Paulo 18, 7–21.
- Srivastava, S.C., 1970. Miofloral investigations in some coals of Talchir Coalfield (Orissa) India. *Palaeobotanist* 18, 154–166.
- Staplin, F.L., Pocock, S.J., Jansonius, J., 1967. Relationships among gymnospermous pollen. Rev. *Palaeobot. Palynol.* 1, 297–310.
- Stephenson, M.H., Filatoff, J., 2000. Correlation of Carboniferous–Permian palynological assemblages from Oman and Saudi Arabia. In: Al-Hajri, S., Owens, B. (Eds.), *Stratigraphic Palynology of the Palaeozoic of Saudi Arabia*. Geo-Arabia Spec. Publ. 1. Gulf PetroLink, Manama, Bahrain, pp. 168–191.
- Taylor, T.N., 1982. Ultrastructure studies of Paleozoic seed fern pollen: sporoderm development. Rev. *Palaeobot. Palynol.* 37, 21–53.
- Tiwari, R.S., 1965. Miospore assemblage in some coals of Barakar Stage (Lower Gondwana) of India. *Palaeobotanist* 13, 168–214.
- Traverse, A., Ash, S.R., 1999. Preliminary assessment of the age of the palynoflora of the red Tanks Member, Madera Formation, Carrizo Arroyo, New Mexico. *New Mexico Geological Society Guidebook, 50th Field Conference, Albuquerque Geology*, pp. 293–296.
- Tschudy, R.H., Kosanke, R.M., 1966. Early Permian vesiculate pollen from Texas, USA. *Palaeobotanist* 15, 59–71.
- Venkatachala, B.S., Kar, R.K., 1968. Palynology of the north Karanpura Basin, Bihar, India –2. Barakar exposures near Lungatoo, Hazaribagh District. *Palaeobotanist* 16, 258–269.
- Vergel, M.M., 1986a. Palinología del Paleozoico superior en la perforación YPF SF J es-1 (Josefina), provincia de Santa Fe, Argentina. I. Anteturma Proximegerminantes. *Ameghiniana* 23, 141–153.
- Vergel, M.M., 1986. Consideraciones paleoecológicas sobre palinofloras neopaleozoicas de la Cuenca Chacoparanense, República Argentina. *Proceedings, 4th Congr. Argentino Paleontol. Bioestratigr.*, Mendoza, Vol 1, pp. 221–225.
- Vergel, M.M., 1987. Consideraciones sobre el contenido microfiorístico de la perforación YPF SE AB (Paleozoico superior), Arbol Blanco, provincia de Santiago del Estero, Argentina. *Proceedings, 7th Simp. Argentino Paleobot. Palinol.*, Buenos Aires, Vol. 1, pp. 75–78.
- Vergel, M.M., 1987b. Palinología del Paleozoico superior en la perforación YPF SF J (Josefina), Provincia de Santa Fé, Argentina. II. Anteturma Variegerminantes. *Ameghiniana* 24, 67–80.
- Vergel, M.M., 1987. Contenido palinológico de la Formación Melo (Paleozoico superior) de Melo, Uruguay. *Proceedings, 10th Congr. Geol. Argentino, San Miguel de Tucumán, Vol. 3*, pp. 117–120.
- Vergel, M.M., Luna, F., 1992. Registros palinológicos en sedimentos del Neopaleozoico de la Sierra de Paimán, La Rioja, Argentina. *Acta Geol. Lilloana* 17, 161–168.
- Visscher, H., 1966. Palaeobotany of the Mesophytic III. Plant microfossils from the Upper Bunter of Hengelo, The Netherlands. *Acta Bot. Neerl.* 15, 316–375.
- Visscher, H., Brugman, W.A., 1981. Ranges of selected palynomorphs in the Alpine Triassic of Europe. Rev. *Palaeobot. Palynol.* 34, 115–128.
- Vázquez Nístico, B., Césari, S.N., 1987. Nuevos elementos paleoflorísticos de la Formación Guandacol (Carbonífero) en la Cuesta de Huaco, provincia de San Juan. *Proceedings, 7th Simp. Paleobot. Palinol.*, Buenos Aires, Vol. 1, pp. 71–74.
- Wilson, L.R., 1962. Permian plant microfossils from the Flowerpot Formation, Greer County, Oklahoma. *Oklahoma Geol. Surv. Circ.* 49, 50 pp.
- Wood, G.D., Wahlman, G.P., Groves, J.R., Brenckle, P.L., 1997. Palynomorphs, smaller foraminifera, fusulinaceans and associated calcareous microfossils from the Copacabana Formation (Pennsylvanian-Lower Permian), Peru. Abstracts, 18th IAS-Regional European Meeting of Sedimentology and 2nd European Meeting on the Paleontology and Stratigraphy of South America, Heidelberg, 1997, p. 366.
- Wood, G.D., Groves, J.R., Wahlman, G.P., Brenckle, P.L., Aleman, A.M. 1999. The paleogeographic and biostratigraphic significance of smaller foraminifera, fusulinaceans and palynomorphs, from the Copacabana Formation (Pennsylvanian-Permian), Madre de Dios basin, Peru. Poster, 14th Int. Congr. Carboniferous-Permian, Calgary, AB.
- Wood, G.D., Elsik, W.C., 1999. Paleoecologic and Stratigraphic importance of the fungus *Reduviasporonites stoschianus* from the ‘Early-Middle’ Pennsylvanian of the Copacabana Formation, Peru. *Palynology* 23, 43–53.
- Zhou, Y.X., 1993. A revised palynological sub-division of the Namurian of Jing-yuan, northwest China. Rev. *Palaeobot. Palynol.* 77, 273–300.
- Zhou, Y.X., 1994. Earliest pollen-dominated microfloras from the early Late Carboniferous of the Tian Shan Mountains, NW China: their significance for the origin of conifers and palaeophytogeography. Rev. *Palaeobot. Palynol.* 81, 193–211.