AMEGHINIANA (Rev. Asoc. Paleontol. Argent.) - 40 (4): 545-558. Buenos Aires, 30-12-2003 ISSN 0002-7014

Palynostratigraphy and paleoenvironments of Early Jurassic strata (Nestares Formation) in northern Patagonia, Argentina. Part 1. Terrestrial species

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Abstract. A palynologic analysis is presented of the Early Jurassic Nestares Formation at its type locality, on both sides of the Limay river, Alicurá dam, at Neuquén and Río Negro provinces boundary, northern Patagonia, Argentina. In this first part the terrestrial species (spores and pollen grains) of the microflora are listed, illustrated and, in some cases, commented on. The geologic context is reviewed and different paleoenvironmental interpretations, one as a paralic sequence and another as an anastomosing fluvial system, both based on earlier sedimentologic studies, are considered. The microflora is compared with the known record of the megaflora and the botanical affinities of the components of the microflora are proposed. Thirty nine of the species of miospores illustrated and listed are recorded for the first time in the Early Jurassic of Argentina. The terrestrial taxonomic diversity is represented by 48 species of Bryophyte / Pteridophyte spores and 23 species of Gymnospermous pollen grains, *versus* five species of Pteridophytes and 17 Gymnosperm species known from the the megaflora; thus the microfloristic biodiversity record is larger than the megafloristic one.

Resumen. PALINOESTRATIGRAFÍA Y PALEOAMBIENTES DE ESTRATOS DEL JURÁSICO TEMPRANO (FORMACIÓN NESTARES) EN EL NORTE DE PATAGONIA, ARGENTINA. Parte 1. Especies Terrestres. Se presenta un analisis palinológico de la Formación Nestares (Jurásico Temprano) en su localidad tipo, a ambos lados del río Limay, represa de Alicurá en el límite de las provincias de Neuquén y Río Negro, norte de Patagonia, Argentina. En esta primera parte se listan, ilustran y, en algunos casos, se comentan las especies terrestres (esporas y granos de polen) de las cuales 39 se registran por primera vez en el Jurásico Temprano de la Argentina. Se da un resumen del contexto geológico donde dos diferentes interpretaciones paleoambientales, basadas en estudios sedimentológicos previos, fueron planteadas: una como una secuencia parálica y la otra como un sistema fluvial anastomosado. Se compara la microflora con el registro previo conocido de la megaflora y se presentan las afinidades botánicas de los componentes de la microflora. La diversidad taxonómica está representada por 48 especies de esporas de briófitas / pteridófitas y 23 especies de granos de polen en comparación con 5 especies de pteridófitas y 17 especies de gimnospermas de la megaflora, por lo que el registro de la diversidad microflorística es mayor que el megaflorístico.

Key words. Palynology. Early Jurassic. Patagonia. Argentina. Terrestrial species.

Palabras clave. Palinología. Jurásico Inferior. Patagonia. Argentina. Especies terrestres.

Introduction

The present contribution is the first part of a palynostratigraphic, paleoenvironmental and paleoclimatic study of the Nestares Formation at its type locality, at both margins of Limay River, Alicurá dam locality, Neuquén and Río Negro provinces. In this first part the terrestrial species of palynomorphs are listed and illustrated. In some cases systematic remarks are given.

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Previously two different environmental interpretations had been proposed through analysis of the sedimentological register of the Formation. One of them is that of a paralic environment which mediates between the continental and marine facies and applies, in this case, to tidal flats and deltaic bays (Rosenfeld, 1981). On the other hand, the deposits of the Nestares Formation are interpreted as those of an anastomosing fluvial system (Spalletti, 1996).

This study is based on new sampling of the total sequence outcropping at Alicurá locality by one of the authors (A.M.Z.). The new results increase significantly and complement the previous palynologic knowledge on the Early Jurassic of Patagonia. In the same way it supplies a notable increment of paleobiodiver-

 AMGHB2-0002-7014 / 03$00.00+.50

sity through the new records of paleomicroplankton and additional taxa of pollen and spores.

In a second part the numerous aquatic species of the Nestares microflora will be described and illustrated and their environmental significance will be considered. In a last, concluding part, the paleoenvironment and paleoclimate of this sequence will be redefined, based on statistic analysis of the microfloristic assemblages and new advances in the knowledge of the extension of stratigraphic ranges of taxa worldwide which contribute to a more precise definition of the age of the palynoflora.

Geological setting

The Nestares Formation of Early Jurassic age, is located in the southeastern part of the Neuquén Basin, which is a southern extension of the larger Chilean Basin. The geology of these outcrops at Alicurá locality and / or neighbouring areas has been studied, amongst others, by Nullo (1979), Quartino *et al.* (1981), Volkheimer *et al.* (1981), Lapido *et al.* (1984), Arrondo *et al.* (1991), Spalletti *et al.* (1992) and Spalletti (1996).

Spalletti (1996, p.267) mentions that the Jurassic Nestares Formation lies conformably on continental uppermost Triassic conglomerates and sandstones of the Paso Flores Formation, "which have been interpreted as belonging to an alluvial fan and gravelly-and sandy-dominated braided system which towards the more distal areas interfinger with lacustrine mudstones and sandstones". However, it is important to mention that the stratigraphic contact between the uppermost Triassic Paso Flores Formation and the Early Jurassic Nestares Formation cannot be observed at the surface and no drilling core is available in order to observe the stratigraphic relation between both formations. The sedimentary cover of the Nestares Formation is of Quaternary age (figure 1).

Quartino *et al.* (1981) named as Las Coloradas Formation the Jurassic outcrops at Alicurá and at Las Coloradas canyon, a right tributary of Limay river and expressed the probability that this Formation is overlying the Paso Flores Formation, which is outcropping 10 km to the east. Nevertheless, by priority reasons, the name Nestares Formation (González Díaz, in Arrondo and Petriella, 1982) has to be used (see Quattrocchio and Damborenea, 1993, pp: 221–222; 281–282).

"The Jurassic succession is 240m thick and is composed of two principal lithologic associations: on the one hand pink–greish granule conglomerates and coarse sandstones, and on the other hand black shales and mudstones, coal shales and thin coal layers" (Spalletti, 1996) (figure 1B). For a very complete sedimentologic and tectonic analysis of the Nestares sequence see Spalletti *et al.* (1992).

Material and methods

The palynologic assemblages were obtained from grey claystones from the lower and middle part of the outcropping section, on both margins of the Limay river (figure 1 A and B).

The physical and chemical extraction of the palynomorphs was carried out by Alejandra Moschetti in the Paleopalynology Laboratory of IANIGLA / CRICYT (CONICET) in Mendoza following the conventional palynologic techniques used in this laboratory (Volkheimer y Melendi, 1976). The palynologic slides are stored in the Paleopalynology Collection of the Department of Geology and Paleontology under the numbers 6944, 6952, 6953, 7184, 7188, 7194, 7195, 7197 to 7199, 7233, 7235 and 7242 MPLP (Mendoza–Paleopalinoteca–Laboratorio–Paleopalinología. The coordinates indicated in the illustrations correspond to the microscope Dialux 20 of the Paleopalynology Unit of IANIGLA. The photomicrographs were obtained using Agfapan Film APX 100.

The half–tone illustrations have been grouped according to morphologic criteria. However, the taxonomic list of species follows an alphabetic order (within both large groups of bryophytic and pteridophytic spores and pollen grains).

Due to space limitations the half–tone illustrations are restricted to species of chronostratigraphic and paleoecologic value, those species which appear for the first time in Early Jurassic strata of the Neuquén Basin and species not classified systematically.

Previous palynologic studies

An extensive palynologic study of the Alicurá outcrops was published by Volkheimer *et al.* (1981). It included the description of a detailed stratigraphic section, distinguishing 33 sequences of deltaplain deposits of the middle part of the Nestares Formation (ex Las Coloradas Formation), with 51 species of spores and pollen and five aquatic species, establishing a pre–Upper–Toarcian Liassic age and a transitional (marginal marine) environment for the Formation. An additional characterization of the palynoflora was given by Volkheimer (1984).

A comparison of the latest Triassic and Early Jurassic microfloristic assemblages from Alicurá and neighboured areas of southern Neuquén was reviewed by Zavattieri and Volkheimer (2001).

In the present paper additional taxa of sporomorphs are recorded for these earliest Liassic microfloras of Argentina, thus contributing to a better paleoenvironmental understanding.

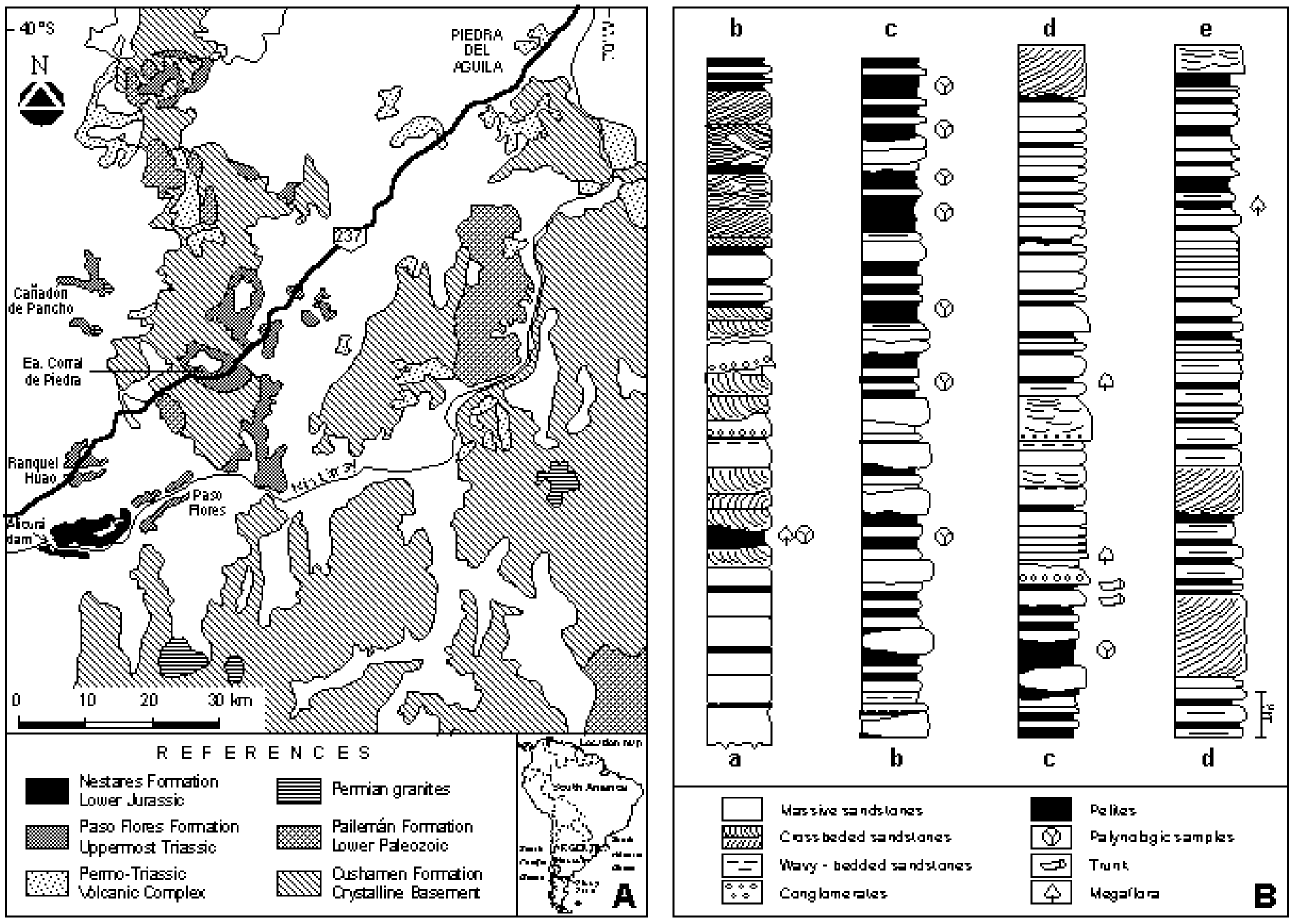


Figure 1. A. Geographic location and outcrop geology of the studied area. Adapted from Spalletti *et al.*, 1992 / *Localización geográfica y geología superficial del área de estudio, adaptado de Spalletti* et al., *1992*. B. Schematic section of the Nestares Formation at the type locality, Limay river (Alicurá dam, Río Negro and Neuquén provinces boundary). Adapted from Spalletti *et al.*, 1992 / *Sección esquemática de la Formación Nestares en su localidad tipo, río Limay (represa de Alicurá, límite entre las provincias de Rio Negro y Neuquen, adaptado de Spalletti,* et al.*, 1992.*

Taxonomic list of identified species

Bryophyte and Pteridophyte Spores

Acanthotriletes pallidus de Jersey, 1960. Figure 4.P
Alsophilidites kerguelensis Cookson, 1947
Antulsporites distaverrucosus (Brenner) Archangelsky and Gamerro, 1966. Figure 4.W
Antulsporites varigranulatus Reiser and Williams, 1969. Figure 4.C
Antulsporites sp. B (in McKellar, 1974). Figure 3.O
Anapiculatisporites dawsonensis Reiser and Williams, 1969. Figure 4.L
Auritulinasporites scanicus Nilsson, 1958. Figure 3.E
Baculatisporites comaumensis (Cookson) Potonié, 1956
Baculatisporites tenuis Volkheimer, 1968. Figure 4.Y
Biretisporites spp.
Calamospora mesozoica Couper, 1958
Calamospora tener (Leschik) de Jersey, 1962. Figure 3.C
Ceratosporites helidonensis de Jersey, 1971 a. Figure 4.J
Cingulatriletes sp. cf. *C. clavus* (Balme) Dettmann, 1963. Figure 3.P
Clavatisporites bagualensis (Volkheimer) Martínez, Quattrocchio and Sarjeant, 2001
Clavatriletes hammenii (Herbst) de Jersey, 1971b. Figure 4.F
Conbaculatisporites mesozoicus Klaus, 1960. Figure 4.D
Concavisporites semiangulatus Menéndez, 1968. Figure 3.R
Concavisporites sp. 7184. Figure 3.M
Converrucosisporites cameronii (de Jersey) Playford and Dettmann, 1965. Figure 4.U
Converrucosisporites sp. cf. *C. variverrucatus* (Couper) Norris, 1969. Figure 4.X
Converrucosisporites sp. (in González Amicón and Volkheimer, 1982). Figure 4.Q
Convolutispora sp. Figure 4.T
Deltoidospora australis (Couper) Pocock, 1970
Deltoidospora minor (Couper) Pocock, 1970. Figure 3.A
Deltoidospora neddeni Pflug, 1953
Dictyophyllidites atraktos Stevens, 1981. Figure 3.F
Dictyophyllidites harrisii Couper, 1958. Figure 3.N
Dictyophyllidites mortoni (de Jersey) Playford and Dettmann, 1965. Figure 3.D
Foveosporites canalis Balme, 1957. Figures 3.V–W
Foveosporites moretonensis de Jersey, 1964. Figure 3.Q
Gleicheniidites senonicus (Ross) Skarby, 1964. Figure 3.X
Leptolepidites verrucatus Couper, 1958. Plate 2, Figure 4.O
Matonisporites crassiangulatus (Balme) Dettmann, 1963. Figure 3.H
Neoraistrickia taylorii Playford and Dettmann, 1965. Figure 4.A
Neoraistrickia trichosa Filatoff, 1975. Figure 4.Z
Neoraistrickia truncata (Cookson) Potonié, 1956. Figure 4.B
Neoraistrickia sp. cf. *N. truncata* (Cookson) Potonié, 1956. Figure 4.S
Osmundacidites araucanus Volkheimer, 1972. Figure 4.K
Osmundacidites diazii Volkheimer, 1972. Figure 4.R
Osmundacidites wellmanii Couper, 1958. Figure 4.I
Polycingulatisporites mooniensis de Jersey and Paten, 1964. Figures 3.L,U
Polypodiaceoisporites tortuosus McKellar, 1974. Figure 3.S
Punctatosporites cf. *scabratus* (Couper) Norris, 1965. Figure 4.AA

DIVISION	CLASS	ORDER	FAMILY	MEGAFLORA	MICROFLORA
Bryophyta					*Stereisporites* spp. ?*Foveosporites canalis*, ?*F. moretonensis*, *Antulsporites distaverrucosus*, *A. varigranulatus*, *Cingutriletes* sp. cf. *C. clavus*, *Polycingulatisporites moonensis*
Tracheophyta (Vascular plants)	Lycopsida	Selaginellales			*Anapiculatisporites dawsonensis*, *Leptolepidites verrucatus*, *Neoraistrickia taylorii*, *N. truncata*, *N. trichosa*, ?*Ceratosporites helidonensis*, *Clavatriletes hammenii*, ?*Convolutispora* sp.
		Lycopodiales			*Retitriletes austroclavatidites*, *R. rosewoodensis*, *R. semimuris*, ?*F. moretonensis*
	Sphenopsida	Equisetales		*Neocalamites carrerei*	*Calamospora mesozoica*, *Calamospora tener*
	Filicopsida	Marattiales		*Marattia münsteri*	*Punctatosporites* cf. *scabratus*
		Filicales	Dicksoniaceae/Cyatheaceae		*Deltoidospora minor*, *D. australis*, *D. neddeni*
			Dipteridaceae/ Matoniaceae/ Cheiropleuriaceae	*Goeppertella diazii*	*Converrucosisporites cameronii*, *Dictyophyllidites atraktos*, *D. harrisii*, *D. mortoni*, *Matonisporites crassiangulatus*
			Gleicheniaceae		?*Todisporites major*, ?*Todisporites minor*, ?*Concavisporites semiangulatus*, *C.* sp., *Gleicheniidites senonicus* ?*Skarbysporites elsendoornii*
			Osmundaceae	*Cladophlebis mendozaensis* *C. oblonga*	*Todisporites major*, *T. minor*, *Baculatisporites comaumensis*, *B. tenuis*, *Clavatisporites bagualensis*, *Osmundacidites diazii*, *O. araucanus*, *O. wellmanii*, *Rugulatisporites neuquenensis*, *Verrucosisporites varians*
			Pteridaceae		*Striatella seebergensis*
			Undifferentiated		*Acanthotriletes pallidus*, *Converrucosisporites* spp., *Lophotriletes* sp. cf. *L. bauhiniae*
	Gymnospermopsida	Caytoniales (Pteridosperms)	Corystospermaceae		*Alisporites lowoodensis*, *A. australis*, *A. similis*, *A.* spp., *Indusiisporites parvisaccatus*, *Sulcosaccispora alaticonformis*
			Caytoniaceae		*Vitreisporites pallidus*
			Peltaspermaceae		*Cycadopites deterius*, *C. granulatus*, *C. reticulatus*
		Pteridosperms *(incertae sedis)*		*Scleropteris vincei*	
		Cycadales	Zamiaceae	*Kurtziana brandmayri* *K. cacheutensis*	*Cycadopites* spp.
		Bennettitales (=Cycadoideales)		*Otozamites albosaxatilis* *O. ameghinoi*, *O. bechei* *O. hislopi*, *O. sueroi* *Ptilophyllum acutifolium*	*Cycadopites* spp.
		Cycadophytes *(incertae sedis)*		*Taeniopteris* sp. *Alicurana artabei* *A. nestarensis*	
		Ginkgoales			*Cycadopites* spp.
		Czekanowskiales			?*Cycadopites* spp.
		Voltziales	Voltziaceae	*Podozamites elongatus*	
		Coniferales	Araucariaceae	*Araucarites* sp.	*Araucariacites australis*, *A. fissus*, *Callialasporites trilobatus*, ?*Inaperturopollenites* spp.
			Cheirolepidiaceae		*Classopollis simplex*, *C. classoides*, *C. intrareticulatus*
			Podocarpaceae	*Elatocladus australis* *E. conferta* *E. plana*	*Phrixipollenites* sp. cf. *P. eurysus*, *Podocarpidites ellipticus*, *Inaperturopollenites* (pars)
			Taxaceae		*Perinopollenites elatoides*

Figure 2. Nestares Formation: comparison of the microfloristic and megafloristic records. For the names of authors of species of megaflora and paleobotanic literature concerning Nestares Formation, see subtitle "Previous records on paleobotany"; for authors of species of microfossils, see "Taxonomic list of identified species" / *Formación Nestares: comparación de los registros micro y megaflorísticos. Para los nombres de los autores de las especies de la megaflora y la literatura paleobotánica relativa a la Formación Nestares, véase "Previous records on paleobotany", para los autores de las especies de microfósiles, véase "Taxonomic list of identified species".*

Retitriletes austroclavatidites (Cookson) Döring, Krutzsch, Mai and Schulz, 1963. Figure 4.H
Retitriletes rosewoodensis de Jersey, 1959. Figure 4.M
Retitriletes semimuris (Danzé–Corsin and Laveine) McKellar, 1974. Figure 4.N
Rugulatisporites neuquenensis Volkheimer, 1972. Figure 4.V
Skarbysporites elsendoornii Van Erve, 1977. Figures 3.I–J
Stereisporites spp.
Striatella seebergensis Mädler, 1964b. Figures 3.K,T
Todisporites major Couper, 1958
Todisporites minor Couper, 1958. Figure 3.B
Todisporites cinctus (Malyavkina) Orlowska–Zwolinska, 1971. Figure 3.G
Verrucosisporites cf. *opimus* Manum, 1962 . Figure 4.G
Verrucosisporites varians Volkheimer, 1972. Figure 4.E

Gymnospermae Pollen Grains

Alisporites grandis (Cookson) Dettmann, 1963. Figure 5.A
Alisporites lowoodensis de Jersey, 1963. Figure 5.C
Alisporites similis (Balme) Dettmann, 1963. Figure 5.H
Araucariacites australis Cookson, 1947. Figure 5.V
Araucariacites fissus Reiser and Williams, 1969. Figure 5.P
Callialasporites turbatus (Balme) Schulz, 1967. Figure 5.S
Classopollis simplex (Danzé, Corsin and Laveine) Reiser and Williams, 1969. Figure 5.M
Classopollis intrareticulatus Volkheimer, 1972. Figure 5.R
Classopollis classoides (Pflug) Pocock and Jansonius, 1961.
Cycadopites granulatus (de Jersey) de Jersey, 1964. Figure 5.Q
Cycadopites reticulatus (Nilsson) Cornet and Traverse, 1975. Figures 5.D, K
Inaperturopollenites sp. Figures 5.L, T–U
Indusiisporites parvisaccatus (de Jersey) de Jersey, 1963. Figure 5.F
Perinopollenites elatoides Couper, 1958. Figure 5.N
Phrixipollenites sp. cf. *P. eurysus* Haskell, 1968. Figure 5.E
Podocarpidites ellipticus Cookson, 1947. Figure 5.I
Pityosporites parvisaccatus de Jersey, 1960. Figure 5.J
Sulcosaccispora alaticonformis (Malyavkina) de Jersey, 1968. Figure 5.G
Trisaccites sp. Figure 5.B
Vitreisporites pallidus (Reissinger) Nilsson, 1958. Figure 5.O

Remarks on systematic palynology

In this section the systematic position of some problematic genera will be discussed: *Retitriletes*, *Skarbysporites* and *Striatella* (= *Duplexisporites*). On the other hand some remarks on species of uncertain position are given. We treat the taxa in alphabetic order.

Genus ***Biretisporites*** Delcourt and Sprumont *emend.* Delcourt, Dettmann and Hughes, 1963

Type species. *Biretisporites potoniaei* Delcourt and Sprumont, 1955.

Biretisporites spp.

In *Biretisporites* spp. we included a variety of forms that cannot be accomodated satisfactorily within species described earlier of this genus. This group consists of smooth trilete spores, triangular to rounded triangular in outline and Y scar bordered by conspicuous elevated lips.

Genus ***Concavisporites*** Pflug, 1953 *emend.* Delcourt and Sprumont, 1955

Type species (by original designation in Thomson and Pflug, 1953, p. 49). *Concavisporites rugulatus* Pflug, 1953.

Concavisporites sp.
Figure 3.M

Remarks. Under this designation we group numerous forms of laevigate spores with triangular amb. Most of them are more or less concave in outline but there exist transitions to specimens with straight or even slightly convex sides. A constant feature is the presence of well developed kyrtomes which accompany the Y scar and surround its angles. The size range is from 34 to 59 µm in diameter. Earlier authors have created several species which include the mentioned forms, but our material shows that there are transitions between them which indicate an intraspecific variability. We will treat their systematics in a separate paper, considering that they are an important component of Rhaeto–Liassic microfloras worldwide.

Genus ***Converrucosisporites*** Potonié and Kremp, 1954

Type species. *Converrucosisporites triquetus* (Ibrahim) Potonié and Kremp, 1954.

Converrucosisporites sp. cf. ***C. variverrucatus*** (Couper) Norris, 1969
Figure 4.X

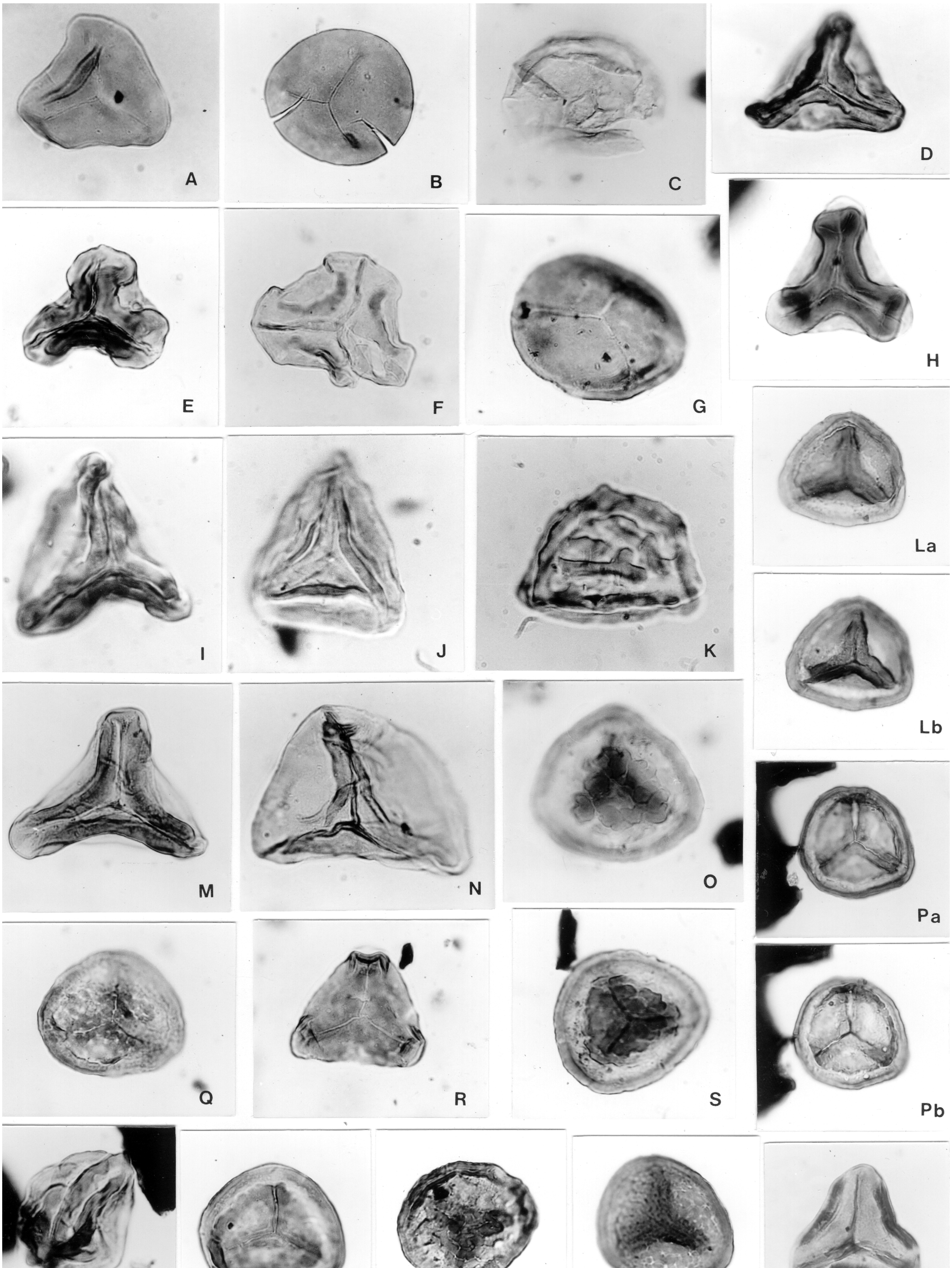
Remarks. Specimens of this material have coarser and more broadly distributed verrucae than *C. variverrucatus*.

Genus ***Convolutispora*** Hoffmeister, Staplin and Malloy, 1955

Type species. *Convolutispora florida* Hoffmeister, Staplin and Malloy, 1955.

Convolutispora sp.
Figures 4.Ta, b

Remarks. The single specimen figured in 4 Ta, b meets the generic features of *Convolutispora*, in having circular to subcircular outline, and ornamentation of closely packed, anastomosing vermiculate ridge–like elements, causing a convoluted appearance. Due to the orientation, the trilete rays cannot be observed.
Comparison. The specimen could also be compared with *Tigrisporites jonkeri* Van Erve (1977) from the Lower Jurassic of the Vicentinian Alps, but it is not possible to observe the presence of a distal polar thickening without rugulate ornamentation, which characterizes the genus *Tigrisporites.* Besides, our specimen is much smaller in size (34 µm) than *T. jonkeri* (47 µm). *Convolutispora microrugulata* Schulz, 1967 has smaller vermiculate–rugulate sculpture.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Lycopodiacidites cerebriformis (Naumova ex Bolchovitina, 1953) Semenova, 1970 as illustrated by Van Erve (1977, p. 60, pl. 9, 1–3) has prominent trilete rays extended to the equator and is larger in size (60 µm).

Genus ***Inaperturopollenites*** Pflug and Thomson in Thomson and Pflug *emend*. Potonié, 1966

Type species (by original designation). *Inaperturopollenites dubius* (Potonié and Venitz) ex Thomson and Pflug, 1953.

Inaperturopollenites sp.
Figures 5.L, T, U

Description. Pollen grains circular to subcircular in outline, frequently distorted by heavy folding, tangentially to the margins; some have folds extending almost round the equator (figure 5.U) or partially to it (figure 5.L). However, transitional forms to those unfolded have been observed (figure 5.T). Exine smooth and thick, ca. 2–2,5 µm. No germinal mechanism is visible. Diameter (based on 8 specimens): 89 to 105 µm.
Remarks. The principal features of the Nestares' specimens are the frequent development of marginal folds (Figures 5 T–U), the thickness of the exine and the large size of the grains.

Genus *Neoraistrickia* Potonié, 1956

Type species (by original diagnosis): *Neoraistrickia truncata* (Cookson) Potonié, 1956.

Neoraistrickia sp. cf. ***N. truncata***
(Cookson) Potonié, 1956
Figure 4.S

Remarks. There is a single specimen in the Nestares material showing strongly concave sides and conspicuously truncate bacula which are larger than those of *N. truncata*, species with which we compare rather than identify it. On the other hand, *N. taylorii* Playford and Dettmann, 1965, has spinulate elements besides the bacula. Our specimen cannot be included in *Concavissimisporites* Delcourt and Sprumont, 1955 *emend*. Fensome, 1987, which admits only forms with an ornament of predominantly unit sculpture of smaller elements (granulae, verrucae or occasionally, tuberculae or short baculae). Equatorial diameter without bacula: 55 µm.

Genus ***Phrixipollenites*** Haskell, 1968

Type species. *Phrixipollenites infrulus* Haskell, 1968.

Phrixipollenites sp. cf. ***P. eurysus***
Haskell, 1968
Figure 5.E

The figured specimen agrees closely with that illustrated and described as *Phrixipollenites* sp. cf. *P. eurysus* Haskell by Arguijo and Volkheimer (1985) from the Lower Jurassic of Piedra Pintada Formation, in the Neuquén Basin.

Genus ***Retitriletes*** Pierce *emend*.
Döring, Krutzsch, Mai and Schulz, 1963

Type Species (by original designation). *Retitriletes globosus* Pierce, 1961.
Remarks. As stated in the Genera File of Fossil Spores of Jansonius and Hills (1976, card 1545), the genus *Lycopodiumsporites* is considered as a *nomen dubium.* We include all species previously assigned to that genus, into *Retitriletes*, if they meet the emended diagnosis of Döring, Krutzsch, Mai and Schulz (in Krutzsch 1963, Atlas, Pt. II, p. 8), reproduced on card 2404 of the above mentioned genera file.

The species identified in this microflora are *R. austroclavatidites* (figure 4 H), *R. rosewoodensis* (figure 4 M) and *R. semimuris* (figure 4 N).

Genus ***Skarbysporites*** Van Erve, 1977

Type species. *Skarbysporites elsendoornii* Van Erve, 1977.

Skarbysporites elsendoornii Van Erve, 1977
Figures 3.I, J

Remarks. Interradial equatorial exinal thickening and the presence of well developed proximal kyrtomes are the main features which distinguish this genus from other similar genera like *Gleicheniidites*, *Concavisporites*, *Auritulinasporites*, *Dictyophyllidites*, *Toricingulatisporites*, *Kyrtomisporis* and others. De Jersey and Raine (1990, p. 40) mention that *"Skarbysporites"* Van Erve

Figure 3. All figures x 700, except I, J, K x 900. *Todas las figuras ampliadas x 700, excepto I, J, K x 900.* **A,** *Deltoidospora minor* (Couper) Pocock. 7198 c: 26.4/107.0 MPLP. **B,** *Todisporites minor* Couper. 7235 b: 32.6/99.6 MPLP. **C,** *Calamospora tener* (Leschik) de Jersey. 7194 e: 31.9/97.33 MPLP. **D,** *Dictyophyllidites mortoni* (de Jersey) Playford and Dettmann. 7195 c: 27./103.5 MPLP. **E,.** *Auritulinasporites scanicus* Nilsson. 7195 c: 39.0/109.3 MPLP. **F,** *Dictyophyllidites atraktos* Stevens. 7195 d: 40.3/104.8 MPLP. **G,** *Todisporites cinctus* (Maljavkina) Orlowska–Zwolinska. 7195 c: 25.5/100.8. **H,** *Matonisporites crassiangulatus* (Balme) Dettmann. 7198 a: 26.0/106.6 MPLP. **I,** *Skarbysporites elsendoornii* Van Erve. 7195 e: 31.8/ 97.8 MPLP. **J,** *Skarbysporites elsendoornii* Van Erve. 7195 e: 28.8/100.6 MPLP. **K,** *Striatella seebergensis* Mädler. 7195 b: 35.9/101.0 MPLP. **L,** *Polycingulatisporites mooniensis* de Jersey and Paten. 7190 b: 30.0/94.1 MPLP. a. median focus; b. proximal focus. **M,** *Concavisporites* sp. 7184 E: 28.0/95.8 MPLP. **N,** *Dictyophyllidites harrisii* Couper. 7195 D: 25.0/93.7 MPLP. **O,** *Antulsporites* sp. B (in McKellar, 1974). 7194 e: 43.0/97.4 MPLP. **P,** *Cingulatriletes* sp. cf. *C. clavus* (Balme) Dettmann. 7190 b: 30.0/94.1 MPLP; a. proximal focus; b. median focus showing a roughly distal polar thickening. **Q,** *Foveosporites moretonensis* de Jersey. 7184 b: 31.8/103.4 MPLP. **R,** *Concavisporites semiangulatus* Menéndez. 7194 b: 34.6/112.2 MPLP. **S,** *Polypodiaceoisporites tortuosus* McKellar. 7197 d: 45.0/100.8 MPLP. **T,** *Striatella seebergensis* Mädler. 7188 e: 31.0/93.0 MPLP. Equatorial view. **U,** *Polycingulatisporites mooniensis* de Jersey and Paten. 7184 b: 36.0/114.1 MPLP. **V,** *Foveosporites canalis* Balme. 7184 e: 43.7/105.0 MPLP. **W,** *Foveosporites canalis* Balme. 7199 a: 40.0/112.6 MPLP. **X,** *Gleicheniidites senonicus* (Ross) Skarby. 7241 a: 39.2/95.4 MPLP.

(1977), may be a junior synonym of *Toricingulatisporites* Simoncsics (1964). The main point of possible difference being the extent of continuation of the cingulum at the apices". As stated by de Jersey and Raine (1990), the second species of *Skarbysporites*, *S. puntii*, despite the description, does not show clearly a discontinuity of the equatorial thickening at the apices, but only a reduction in thickness of the cingulum at the apices. We don't share the idea of a possible synonymy of *Skarbysporites* and *Toricingulatisporites*, considering that the interradial thickening of *Skarbysporites* is a striking difference which distinguishes this genus clearly from *Toricingulatisporites*. The original diagnosis of the latter does not mention at all the presence of interradial thickenings. A restudy of *S. puntii* could lead, eventually, to the inclusion of this species into a different genus.

Genus ***Stereisporites*** (Pflug) de Jersey, 1964

Type species (original designation in Thomson and Pflug, 1953). *Stereisporites stereoides* (Potonié and Venitz) Pflug, 1953.

Stereisporites spp.

In the Nestares microflora there is a number of trilete spores of small size (20–40 µm), convexly triangular to circular in outline and the equatorial exine thickened to form a ring or cingulum. The trilete mark is accompanied by thickened lips. Forms with a distal polar thickening or such with a distal variable sculpture are present and all of them can be accomodated under the genus *Stereisporites*. A satisfactory taxonomic treatment of these forms requires a more detailed study of them. This type of spores has sphagnacean affinity by comparison with those of *Sphagnum* (Filatoff, 1975, p. 36).

Genus ***Striatella*** Mädler, 1964b *emend.* Filatoff and Price, 1988

1964b *Striatella* Mädler, p. 189
1977 *Asseretospora* Schuurman, p. 197
1978 *Rotinella* Malyavkina, 1949, *ex* Yaroshenko, p. 60

Type species. *Striatella seebergensis* Mädler, 1964b by original designation.

Remarks. The emended diagnosis of Filatoff and Price (1988), differs from Mädler's diagnosis by interpreting the proximal muri "as being oriented tangentially and associated with the cingulum rather than the tetrad mark in the manner of kyrtomes".

Striatella seebergensis Mädler, 1964b
Figures 3.K, T

Remarks. We accept the use of *Striatella seebergensis* instead of *Duplexisporites problematicus* (*auct. non* Couper) Playford and Dettmann; Helby and de Jersey in de Jersey, 1970b, p. 8, plate 3, figures 1–3. As suggested by Filatoff and Price (1988) and earlier authors cited by them, *Duplexisporites* Deák is an inappropriate repository for *Cingulatisporites problematicus* Couper 1958, which was later emended by Playford and Dettmann (1965) as *Duplexisporites problematicus* (Couper) n. comb.

We consider as *Striatella seebergensis* those specimens which show proximal muri tangential to the cingulum and distal ornamentation with the variability expressed in the emended generic diagnosis of Filatoff and Price (1988). The Argentinian material shows a variability of distal ornamentation identical to that described and illustrated by Australian workers for *Striatella seebergensis* and *Duplexisporites problematicus*: Forms with distal ornamentation forming a more or less continuous spiral, those with somewhat discontinuous muri and others where the muri near the distal pole are dissolved into discrete verrucae.

Comparisons. In *Kyrtomisporis* Mädler (1964b) the proximal muri are associated with the tetrad mark in the manner of kyrtomes, not oriented tangentially and associated with the cingulum, like in *Striatella*. *Asseretospora* Schuurman (1977) is of identical morphology, but a junior synonym. *Aneimites* Kara–Murza and Romanovskaja (in Romanovskaja, 1963) is identical, but illegitimate; *Crassitudosporites* Hiltmann, 1967 lacks proximal tangential muri.

Figure 4. All figures approximately x 700. *Todas las figuras ampliadas aproximadamente x 700.* **A,** *Neoraistrickia taylorii* Playford and Dettmann. 7195 d: 34.0 / 96.8 MPLP. **B,** *Neoraistrickia truncata* (Cookson) Potonié. 7195 C: 23.7 / 100.5 MPLP. **C,** *Antulsporites varigranulatus* Reiser and Williams. 7184 E: 22.5 / 112.5 MPLP. **D,** *Conbaculatisporites mesozoicus* Klaus. 7197 e: 31.4 / 106.3 MPLP. **E,** *Verrucosisporites varians* Volkheimer. 7194 e: 35.3 / 103.9 MPLP. **F,** *Clavatriletes hammenii* (Herbst) de Jersey. 7197 d: 40.6 / 94.8 MPLP. **G,** *Verrucosisporites* cf. *opimus* Manum. 7194 c: 33.0 / 106.0 MPLP. **H,** *Retitriletes austroclavatidites* (Cookson) Döring, Krutzsch, Mai and Schulz. 7195 c: 21.5 / 106.1 MPLP. **I,** *Osmundacidites wellmanii* Couper. 7188e: 42.7 / 107.4 MPLP. **J,** *Ceratosporites helidonensis* de Jersey. 7194 e: 28.8 / 110.7 MPLP. **K,** *Osmundacidites araucanus* Volkheimer. 7235 b: 24.997.8 MPLP. **L,** *Anapiculatisporites dawsonensis* Reiser and Williams. 7235 b: 23.5 / 102.0 MPLP. **M,** *Retitriletes rosewoodensis* de Jersey. 7199 e: 34.9 / 111.0 MPLP. **N,** *Retitriletes semimuris* (Danzé–Corsin and Laveine) McKellar. 7195 c: 22.6 / 96.4 MPLP. **O,** *Leptolepidites verrucatus* Couper, 1958. 7198 a: 42.2 / 105.8 MPLP. **P,** *Acanthotriletes pallidus* de Jersey, 1960. 7194 b: 23.3 / 96.5 MPLP. **Q,** *Converrucosisporites* sp. (in González Amicón and Volkheimer, 1982). 7188 a: 41.8 / 103.6 MPLP. **R,** *Osmundacidites diazii* Volkheimer. 7235 b: 26.5 / 94.3 MPLP. **S,** *Neoraistrickia* sp. cf. *N. truncata* (Cookson) Potonié. 7195 C: 37.5 / 99.9 MPLP. **T,** *Convolutispora* sp. 7198 a: 42.2 / 105.8 MPLP. a. Showing vermiculate rugulae of the ornamentation; b. Showing possible Y scar. **U,** *Converrucosisporites cameronii* (de Jersey) Playford and Dettmann. 7195 c: 25.0 / 104.6 MPLP. **V,** *Rugulatisporites neuquenensis* Volkheimer. 7199 e: 38.0 / 102.0 MPLP. **W,** *Antulsporites distaverrucosus* (Brenner) Archangelsky and Gamerro. 7184 d: 31.1 / 101.5 MPLP. **X,** *Converrucosisporites* sp. cf. *C. variverrucatus* (Couper) Norris. 7188 e: 39.3 / 98.2 MPLP. **Y,** *Baculatisporites tenuis* Volkheimer. 7199 e: 38.3 / 99.0 MPLP. **Z,** *Neoraistrickia trichosa* Filatoff. Plate 2, Fig. 26. 7195 b: 34.5 / 108.8 MPLP. **AA,** *Punctatosporites* cf. *scabratus* (Couper) Norris. 7195 c: 40.8 / 112.4 MPLP.

Genus ***Trisaccites*** Cookson and Pike, 1954

Type species. *Trisaccites microsaccatus* (Couper) Couper, 1960.

Trisaccites sp.
Figure 5.B

Remarks. One specimen assigned to *Trisaccites* has been found in the Nestares microflora. It differs from both species with persistant appearance in Jurassic strata, *T. variabilis* (Dev) Haskell, 1968 and *T. microsaccatus* (Couper) Couper, 1960, because no ornamentation of the central body has been observed, perhaps due to the distal position, but does not seem to be strongly ornamented. On the other hand, sacci are larger than those of the mentioned species. The species of *Podosporites* Rao described and illustrated by Haskell, 1968 have smaller sacci and overall sizes.

The Nestares specimen has a subcircular to subtriangular central body (24 µm), probably with a finely ornamented cappa. Three sacci are surrounding the central body; two of them are distally pendant. The sacci are subtriangular in shape (lenght: 29; breadth 11µm) and finely intrareticulate. Overall size the grain, 34 x 44 µm.

Previous records on paleobotany

Fossil plants from the Nestares Formation, at its type locality, were studied by Arrondo and Petriella (1980, 1982), Artabe (1982), Petriella and Arrondo (1982) and Baldoni (1987). Arrondo *et al.*, (1984) listed the complete record of plant megafossils found in the unit. They belong to the following groups: Equisetales, Filicopsida (Marattiales, Gleicheniaceae and Dipteridaceae), Bennettitales, Coniferales and genera *incertae sedis*, which represent Liassic components (Nullo, 1979) and probably the oldest Early Jurassic flora in Argentina (Arrondo *et al.*, 1991). The paleoflora of the Nestares Formation is composed of Triassic–Jurassic components (*Neocalamites carrerei* (Zeiller) Halle, *Cladophlebis mendozaensis* (Geinitz) Frenguelli, *Podozamites elongatus* (Morris) Feistm., *Elatocladus australis* Frenguelli, *Kurtziana brandmayri* Frenguelli, *K. cacheutensis* Frenguelli, *Taeniopteris* sp., *Alicurana artabei* Herbst and Gnaedinger and *A. nestarensis* Herbst and Gnaedinger, but also contains a restricted Early Jurassic group (*Marattia münsteri* Goeppert, *Goeppertella diazii* Arrondo and Petriella, *Otozamites albosaxatilis* Herbst, *O. ameghinoi* Kurtz, *O. bechei* Brong., *O. hislopi* (Oldhm.), *Ptilophyllum acutifolium* Morris, *Araucarites* sp., *Elatocladus conferta* (Oldham et Morris) Halle, *E. plana* (Feistmantel) Seward, *Scleropteris vincei* Herbst, *Cladophlebis oblonga* Halle) (Arrondo *et al.*, 1991; Herbst and Gnaedinger, 2002).

Microflora compared with megaflora

For classification of the megaflora we have adopted here the systematic scheme of Stewart (1983) and Stewart and Rothwell (1993). On figure 2 the complete register of the megaflora and the terrestrial species of the microflora is presented. It calls the attention that several formgenera of the microflora appear in different families or even orders of the megaflora. That is the case of polyphyletic forms like *Cycadopites* and *Monosulcites*, whose morphology is very simple and which appear within the orders Caytoniales, Cycadales, Bennettittales, Ginkgoales and Chekanowskiales. Nevertheless, at the Class level the attribution of miospore genera is for the most part possible (de Jersey and Raine, 1990).

Particularly, the species mentioned in the column "Microflora" do not necessarily correspond to those in the column "Megaflora". Moreover, the "allround"–biodiversity, as expressed by the microflora, is by far greater than the diversity resulting from the megafloristic record. A striking case is that of the Division Bryophyta, which is represented by 6 species of trilete spores and, in contrast, without representatives in the megaflora. On the other hand, 7 species of trilete spores correspond to the Class Lycopsida and no plant megafossil of the Nestares Formation belongs to this class.

Figure 5. All figures approximately x 700, unless otherwise stated. *Todas las figuras ampliadas aproximadamente x 700, excepto las indicadas*. **A,** *Alisporites grandis* (Cookson) Dettmann. 7235 b: 39.7 / 106.3 MPLP**. B,** *Trisaccites* sp. 7195 d: 25.3 / 95.5 MPLP. **C,** *Alisporites lowoodensis* de Jersey. 7235 b: 29.5 / 103,5 MPLP**. D,** *Cycadopites reticulatus* (Nilsson) Cornet and Traverse. (x 900) 7195 f1: 37.5 / 104.0 MPLP; a. Focus showing reticulate ornamentation; b: Showing the length of the colpus. **E,** *Phrixipollenites* sp. cf. *P. eurysus* Haskell. 7198 c: 27.77 / 101.7 MPLP. **F,** *Indusiisporites parvisaccatus* (de Jersey) de Jersey. 7242 d: 37.7 / 96.8 MPLP. **G,** *Sulcosaccispora alaticonformis* (Malyavkina) de Jersey. 7235 a: 29.3 / 108.7 MPLP. **H,** *Alisporites similis* (Balme) Dettmann. 7195 c: 37.4 / 98.7 MPLP. **I,** *Podocarpidites ellipticus* Cookson. 7242 d: 41.7 / 92.6 MPLP. **J,** *Pityosporites parvisaccatus* de Jersey. 7195 d1: 31.7 / 102.8 MPLP. **K,** *Cycadopites reticulatus* (Nilsson) Cornet and Traverse. (x 900) 7195 d1: 31.7 / 102.8 MPLP. **L,** *Inaperturopollenites* sp.(x 400) 7235 b: 34.8 / 100.9 MPLP. Showing partial tangential fold. **M,** *Classopollis simplex* (Danzé, Corsin and Laveine) Reiser and Williams. 7198 a: 44.7 / 104.9 MPLP. **N,** *Perinopollenites elatoides* Couper. 7194 B: 40.5 / 95.0 MPLP. **O,** *Vitreisporites pallidus* (Reissinger) Nilsson. 7198 a: 43.3 / 105.5 MPLP. **P,** *Araucariacites fissus* Reiser and Williams. 7198 a: 41.6 / 103.9 MPLP. **Q,** *Cycadopites granulatus* (de Jersey) de Jersey. 7195 c: 37.0 / 108.1 MPLP. **R,** *Classopollis intrareticulatus* Volkheimer. 7235 a: 31.0 / 107.9 MPLP. **S,** *Callialasporites turbatus* (Balme) Schulz. 7195 c: 25.4 / 98.3 MPLP. **T,** *Inaperturopollenites* sp. (x 400) 7235 b: 29.1 / 103.7 MPLP. Specimen without tangential folds, but showing the thickness of the exine. **U,** *Inaperturopollenites* sp. (x 400) 7235 b: 29.8 / 107.7 MPLP. Showing almost complete peripherical folds. **V,** *Araucariacites australis* Cookson. (x 550) 7242 B: 38.8 / 112.8 MPLP.

The aquatic species of the microflora (acritarchs, dinoflagellates, coccal green algae) are very diverse in the microflora of the Nestares Formation, but, as they are microorganisms, no mega–records do exist.

Preliminary conclusions

The twelve palynologically fertile levels correspond to the lower and middle thirds of the outcropping section at Alicurá dam, Limay river. The spores of Bryophyta and Pteridophyta predominate over the gymnospermous pollen grains and the aquatic species of the microflora. But the phytomicroplankton is definitely more diverse if compared with earlier results and justifies a second part of this study.

The following species of the terrestrial palynomorphs are new records for the Lower Jurassic of the Neuquén Basin: *Acanthotriletes pallidus*, *Alisporites grandis*, *A. similis*, *Antulsporites varigranulatus*, *A.* sp. B, *Anapiculatisporites dawsonensis*, *Baculatisporites tenuis*, *Calamospora tener*, *Ceratosporites helidonensis*, *Cingulatriletes* sp. cf. *C. clavus*, *Clavatisporites bagualensis*, *Clavatriletes hammenii*, *Conbaculatisporites mesozoicus*, *Converrucosisporites cameronii*, *Converrucosisporites* sp. cf. *C. variverrucatus*, *Converrucosisporites* sp. (in González Amicón and Volkheimer, 1982), *Convolutispora* sp., *Dictyophyllidites atraktos*, *Foveosporites moretonensis*, *Gleicheniidites senonicus*, *Inaperturopollenites* sp., *Indusiisporites parvisaccatus*, *Leptolepidites verrucatus*, *Matonisporites crassiangulatus*, *Neoraistrickia taylorii*, *Neoraistrickia trichosa*, *Neoraistrickia truncata*, *Neoraistrickia* sp. cf. *N. truncata*, *Osmundacidites diazii*, *Osmundacidites wellmanii*, *Pityosporites parvisaccatus*, *Polycingulatisporites mooniensis*, *Polypodiaceoisporites tortuosus*, *Retitriletes rosewoodensis*, *Striatella seebergensis*, *Sulcosaccispora alaticonformis*, *Todisporites cinctus*, *Trisaccites* sp., *Verrucosisporites* cf. *opimus*.

The incoming of *Callialasporites trilobatus* in the Nestares microflora constitutes the oldest register of this genus in southern South America. Only in northern East Siberia (Riding *et al.*, 1999), *Callialasporites* spp. appears in well dated lowermost Toarcian strata and, with doubts, already in the *Amaltheus margaritatus Zone* (Text–Figure 8, p. 14 of Riding *et al.* 1999) of the Late Pliensbachian.

Within the terrestrial spectre the laevigate forms are the dominant elements in all assemblages. The spores representing the Bryophyta and the rest of the Pteridophyta (apiculate forms) follow behind them in order of frequencies.

The statistic analysis based on counts will be part of a third contribution where the paleoenvironmental and paleoclimatic results of this study will be presented. From a first analysis of the studied assemblages results that the composition of the terrestrial microflora indicates a moist environment or, at least, a large availability of water near the areas of deposition, combined with the very good state of preservation of the terrestrial palynomorphs and including the frequent and significant presence of tetrads and even polyads.

In the last part of this study, considering new advances of Liassic palynostratigraphy worldwide, the chronostratigraphic significance of terrestrial and aquatic species of the Nestares Formation will be analized.

Acknowledgements

The authors acknowledge grants of “The Dinosaur Society” (1996–97), USA, CONICET (PIP 4674/96) and the Agency of Scientific Promotions of Argentina (Agencia Nacional de Promoción Científica y Tecnológica) (PICT # 07–08467). The authors also wish to express their gratitude to Drs. Mary E. Dettmann and Mirta Quattrocchio for their help in the revision of the manuscript.

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Recibido: 20 de diciembre de 2002.
Aceptado: 6 de junio de 2003.