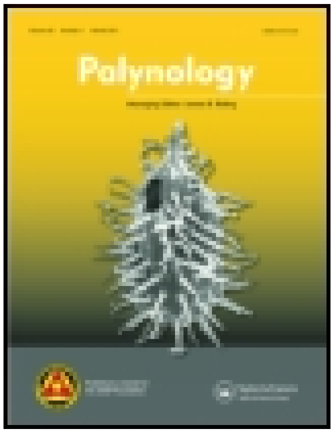

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The palynology of the La Deheza Formation (Carboniferous–Permian; Upper Palaeozoic), Paganzo Basin, San Juan Province, Argentina

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We present the first palynological study of the La Deheza Formation in Paganzo Basin, San Juan Province, Argentina. A total of 18 samples were studied and 116 palynomorph species were recorded. A multivariate statistical (R) analysis confirmed the occurrence of three associations. Assemblages 1 (240 m), 2 (230 m) and 3 (220 m) were referred to biozones already registered in the Paganzo Basin, i.e. *Raistrickia densa–Convolutispora muriornata* (DM), *Pakhapites fusus–Vittatina subsaccata* (FS) and *Lueckisporites–Weylandites* (LW) biozones. These assemblages can be assigned a Pennsylvanian–Cisularian age based on previous stratigraphic records of the identified species.

Keywords: palynology; La Deheza Formation; Upper Palaeozoic; San Juan; Argentina

1. Introduction

Coal prospecting during the late nineteenth century led to the discovery of the outcrops of the La Deheza Formation (Figure 1; see Borrello 1956). The most complete exposures stretch from 35 km north of the San Juan River (31°20′S, at kilometre 69 of the former Ruta Nacional 20) up to the latitude of the Cerro Córdoba (31°50′S, south of Estancia Maradona). In general, these rocks conformably overlie Devonian strata, although a slightly erosive surface has been reported at other localities (Punta Negra Formation, Bracaccini 1950). Cuerda & Furque (1983) characterised the La Deheza Formation exposed at kilometre 69 (Figure 1) as a 557-m-thick sequence representing fluvial and lacustrine palaeoenvironments. Subsequent work focused on the La Deheza Formation outcrops cut by the San Juan River (Figure 1) between kilometre 47 and kilometre 69 (Espejo & López-Gamundí 1984; Milana et al. 1985, 1987; Milana & Bercoswski 1987a, 1987b, 1990; López-Gamundí & Espejo 1988; Lech et al. 1990), in which the authors identified sequences that can be correlated with the formation included in the Paganzo Group.

Currently there are few studies centred on the determination of this unit's age. The first fossils were recorded by Cuerda & Furque (1983), who mentioned the presence of floated fragments of *Paracalamites* sp. in lacustrine mudstones at the base of the section. Based on its lithology, this unit was correlated with the Tupe (Furque 1963), Tuminico (Cuerda et al. 1979) and Río Francia formations (Cuerda & Furque 1981) and, thus, assigned to the Upper Carboniferous.

Further contributions reported the occurrence – at kilometre 63 (Figure 1) – of leaves of *Cordaites* sp. and palynofloras composed of *Lundladispora braziliensis* and *Vallastisporites* sp. (Ramos & Vujovich 2000). These occurrences agree with a mid-Carboniferous to early Permian age (Milana & Bercoswski 1987a). Carboniferous marine invertebrates were identified in the basal sectors of the unit (Milana et al. 1987; Lech et al. 1990).

A recent survey from the top of the La Deheza Formation, north of Estancia Maradona (Figures 1 and 2), yielded fertile palynological samples and abundant Permian floral remains assigned to the *Ferugliocladus* Superzone (Correa et al. 2010; Correa & Gutiérrez 2014).

In this contribution, we provide a characterisation of three palynological assemblages obtained from the study of 17 detailed, fertile samples from the La Deheza Formation, collected north of Estancia Maradona (Figures 1 and2).

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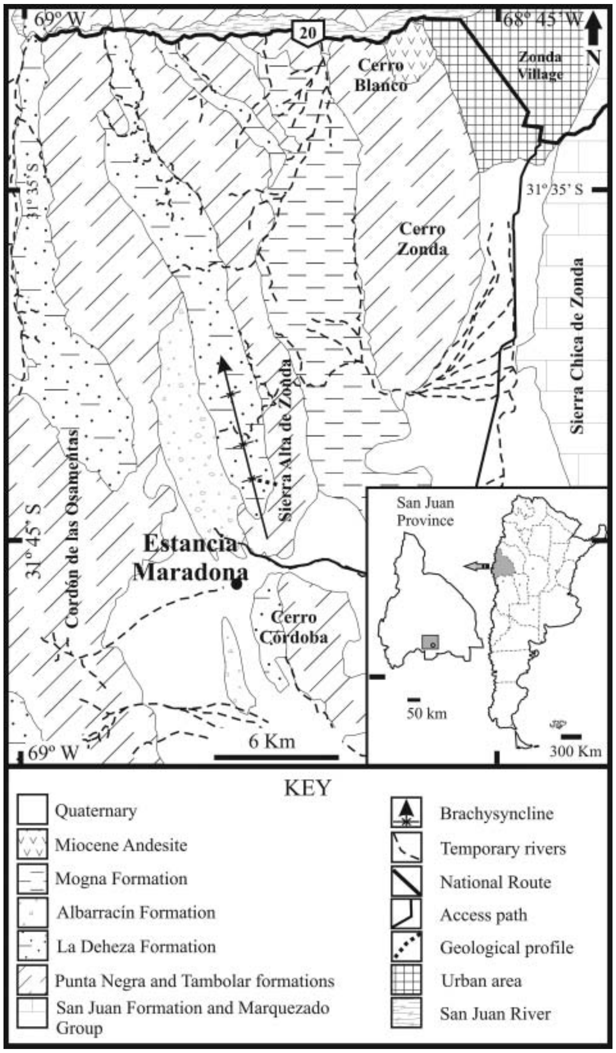

Figure 1. Geological map of the studied area.

2. Geological setting

The La Deheza Formation is extensively exposed to the north of the Estancia Maradona, forming a 690-m-thick brachysyncline structure (Figures 1 and 2) and comprising a diverse sedimentary succession that originated under glaciomarine, fluvial and coastal conditions (Correa & Gutiérrez 2014) and that can be correlated with most of the Paganzo Group.

This unit provides new and enhanced palaeogeographic information on the evolutionary schemes proposed for the Paganzo Basin (Fernández Seveso et al. 1993; Limarino & Spalletti 2006; Net & Limarino 2006). In this context, and following the scheme proposed by Limarino et al. (2006), the La Deheza Formation would span most of Megasequence II (Sequences III and IV) but with visible modifications of the lateral facies arising from the palaeogeographic position of the unit (Figure 3). In the studied area, Sequence III is composed by the lower 320 m of the unit, with its base overlying conformably or slightly tilted on top of the Punta Negra Formation (Figure 2). The upper limit of this sequence is represented by a sixth-order incision surface representing an anastomosing fluvial system (Correa & Gutiérrez 2014). The lower part of Sequence III represents a glacial–postglacial event with dropstones (facies associations I, II and III, early Late Carboniferous). Overlying it is a 30-m-thick package of shales lacking dropstones (facies association IV). Finally, the top of the sequence is characterised by a coal deposit followed by sandstones and coastal shales bearing plant remains, interpreted as a fluvial system (facies associations V and VI).

Sequence IV is 370 m thick with fluvial deposits (facies association VII) and begins with an incision surface (equivalent to the San Rafael tectonic surface, according to Limarino et al. 2006) that represents an anastomosing fluvial system (facies association VII). Above these there is a cyclic succession of eolian, barrier island and lagoon palaeoenvironments filling the upper 280 m of the unit (facies associations VIII, IX and X, according to Correa & Gutiérrez 2014).

3. Materials and methods

We analysed a total of 17 samples recovered from the La Deheza Formation, Central Precordillera, San Juan Province (Figure 1). These were processed following the standard palynological treatment for Palaeozoic material (Wood et al. 1996). One hundred and sixteen palynomorph species were identified (Appendix 1). Specimens are deposited at the 'Colección del Instituto de Ciencias Naturales, Universidad Nacional de San Juan' under the PB SJ acronym. The illustrated elements were located with England Finder coordinates. Photographs were taken with a Nikon DS-Fi1 digital camera with 5 megapixels of resolution, adapted to a Nikon Eclipse 50i optical light microscope at the Sección de Palinología in the Museo Argentino de Ciencias Naturales 'Bernardino Rivadavia'. The supra-generic classification of the spores follows the criteria of Potonié & Kremp (1954) and subsequent modifications (Playford & Dettmann 1996). A multivariate statistical analysis was performed to assess quantitative and qualitative similarities among the palynological samples using the R software Package (R version 3.1.2 (Pumpkin Helmet) 2014, www.r-project.org). Finally, a cluster analysis was included to confirm the associations proposed. Fifty-five genera were used in the data (raw-count) control samples matrix (Appendix 2).

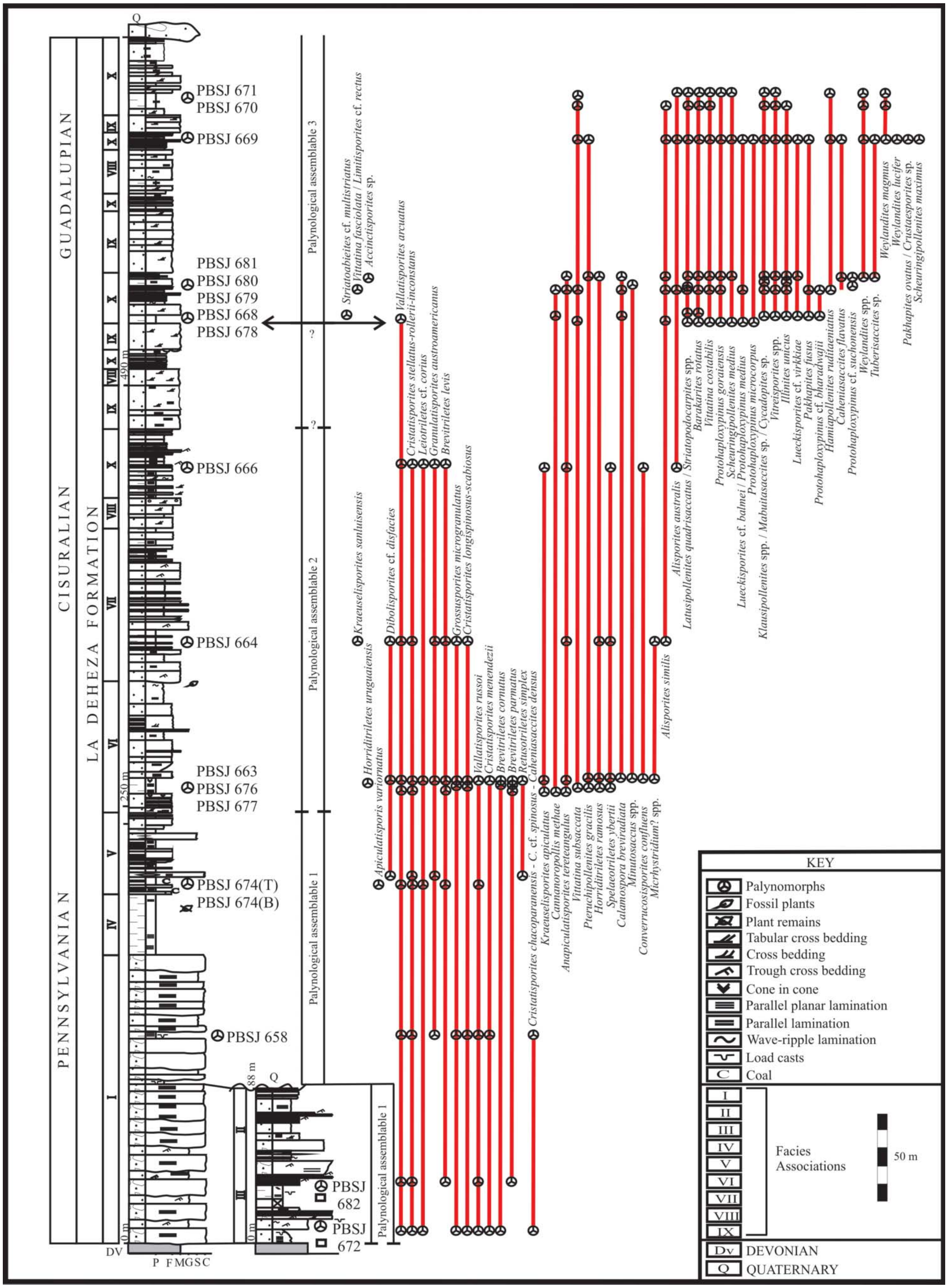

Figure 2. Stratigraphic section of the La Deheza Formation with vertical distribution of selected species.

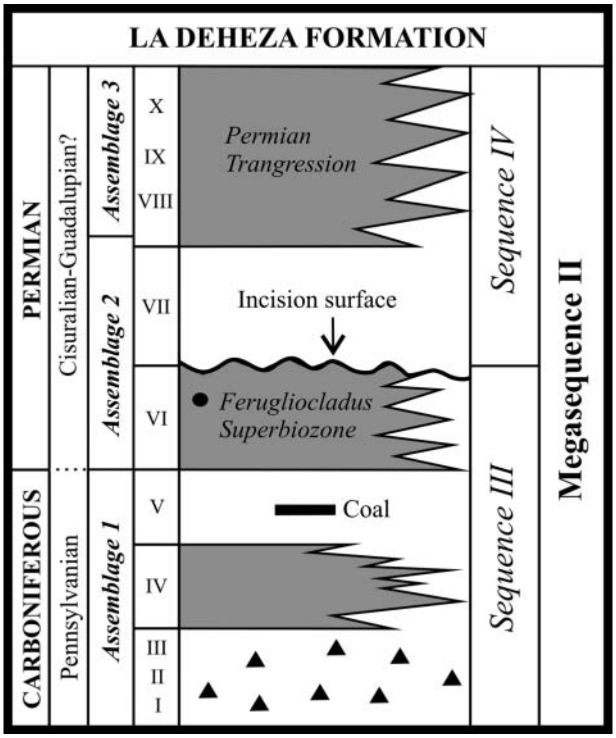

Figure 3. Simplified geological framework of Paganzo Basin (according to Limarino et al. 2006); facies associations from La Deheza Formation (I, II, III, etc.) and major marine ingressions occurring in the latest Carboniferous and Permian are marked. Black triangles indicate the Pennsylvanian post glaciations.

4. Biostratigraphy and ages

The 116 species identified from 18 microfloristical levels allow the characterisation of three palynological assemblages, namely Assemblages 1, 2 and 3 (Tables 1–2; Appendix 3).

4.1. Palynological assemblages

4.1.1. Assemblage 1

Assemblage 1 is dominated by trilete spores (84%, Table 2; Appendix 3). The main components are *Cristatisporites* and *Punctatisporites* species, accounting for more than 50% of the association. *Lundbladispora*, *Grossusporites* and *Leiotriletes* species constitute only about 5% of the palynoflora. Monosaccate pollen grains, fungal spores and algae complete the spectrum. This assemblage includes levels PB SJ 672, 682, 658, 674B, 672T, also identified in facies associations I, II and IV, in the lower 240 m of the La Deheza Formation (Figure 2).

Species restricted to Assemblage 1 are (Figure 2; Table 1): *Apiculatisporis variornatus* (Plate 1, figure 14), *Cristatisporites chacoparanaensis* (Plate 2, figure 1), *C.* sp. cf. *C. sinuosus* (Plate 2, figure 5) and *Caheniasaccites densus* (Plate 2, figure 20). This set of species is in association with other species such as *Brevitriletes cornutus* (Plate 1, figure 15), *B. levis* (Plate 1, figure 20), *B. parmatus* (Plate 1, figure 19), *Cristatisporites stellatus* (Plate 2, figure 10), *C. rolleri* (Plate 2, figure 7), *C. inconstans* (Plate 2, figure 2), *C. longispinosus* (Plate 2, figure 6), *C. scabiosus* (Plate 2, figure 4), *C. menendezi* (Plate 2, figure 3), *Dibolisporites* sp. cf. *D. disfacies* (Plate 1, figure 23), *Granulatisporites austroamericanus* (Plate 1, figure 13), *Grossusporites microgranus* (Plate 1, figure 27), *Leiotriletes* sp. cf. *L. corius* (Plate 1, figure 3), *Retusotriletes simplex* (Plate 1, figure 8), *Spelaeotriletes* spp., *Vallatisporites russoi* (Plate 2, figure 14), *Circumplicatipollis* sp. (Plate 3, figure 1) and *Plicatipollenites malabarensis* (Plate 3, figure 12) which complete the assemblage but are also present in Assemblage 2.

4.1.2. Assemblage 2

Assemblage 2 includes PB SJ 677, 678, 663, 664 and 666 levels (Figure 2) and all are identified in facies associations V, VI and IX (first cycle). The microflora that characterises this assemblage is varied and abundant, with many similar species to Assemblage 1. However, the number of pollen grain species increases and plicate pollen grains such as *Protohaploxypinus*, *Vittatina* and *Minutosaccus* appear for the first time. Also, acritarch specimens (*Micrhystridium*?) are first recorded (Figure 2;Tables 1–2). The top of this distribution assemblage is not clear because in level 666, several species disappear (e.g. *Cristatisporites stellatus*, *Brevitriletes,levis* and *Converrucosisporites confluens*). The limit between Assemblages 2 and 3 (400 m, Figure 2) is indicated with a question mark.

Species with an exclusive distribution include *Converrucosisporites confluens* (Plate 1, figure 17), *Horriditriletes uruguaiensis* (Plate 1, figure 22), *Kraeuselisporites sanluisensis* (Plate 1, figure 26), *K. apiculatus* (Plate 1, figure 25), *Spelaeotriletes ybertii* (Plate 2, figure 11) and *Micrhystridium?* spp. (Plate 5, figures 12, 16). A mix of species belonging to Assemblage 1 and Assemblage 3 complete the spectrum (Figure 2; Appendix 3), including, *Anapiculatisporites tereteangulus* (Plate 1, figure 12), *Calamospora breviradiata* (Plate 1, figure 2), *Horriditriletes ramosus* (Plate 1, figure 21), *Cannanoropollis mehtae* (Plate 3, figure 4), *Alisporites australis* (Plate 4, figure 1), *A. similis* (Plate 4, figure 2), *Minutosaccus* sp. (Plate 4, figure 8), *Pteruchipollenites gracilis* (Plate 4, figure 7) and *Vittatina subsaccata* (Plate 5, figure 15).

4.1.3. Assemblage 3

This association comprises the upper 200 m of the La Deheza Formation, and includes microflora levels PB

Table 1. Distribution of species identified for levels and biozones. References: C-W Argentinian Basins Biozones: DM, *Raistrickia densa–Convolutispora muriornata* Biozone; FS, *Pakhapites fusus–Vittatina subsaccata* Biozone; LW, *Lueckisporites–Weylandites*; Andap., Andapaico Formation. Modified from Césari & Gutiérrez (2001); Césari & Limarino (2002); Perez Loinaze & Césari (2004); Balarino & Gutiérrez (2006); Gutiérrez & Barreda (2006); Gutiérrez & Limarino (2006); Vergel (2008); di Pasquo et al. (2010); Gutiérrez et al. (2010, 2011); Perez Loinaze et al. (2011); Balarino et al. (2012); Correa et al. (2012); Perez Loinaze & Césari (2012); Césari et al. (2013); Perez Loinaze et al. (2014); Archangelsky et al. (2014).

	La Deheza Formation																					Andap. Fm.	
Species/PB SJ*	672	682	658	674B	674T	677	676	663	664	666	678	668	679	680	681	669	670	671	Biozones			Facies association I	Facies association VII
Palynological assemblages			1					2							3								
Facies associations	II		I	IV		V			VI	IX	IX								DM	FS	LW		
***Calamospora* spp.**	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					
***Leiotriletes* spp.**	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					
***Punctatisporites* spp.**	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				•	•
***Lundbladispora* spp.**	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X				•	
***Caheniasaccites* spp.**	X		X	X		X	X	X	X	X		X	X	X	X	X	X	X				•	•
***Retusotriletes* spp.**	X	X	X		X	X	X	X	X	X		X	X		X			X					
Punctatisp.* cf. *gretensis	X	X	X		X	X	X	X	X	X	X				X			X	+	+	+	•	
Leiotriletes directus	X	X	X			X	X	X	X		X	X		X				X	+	+	+	•	•
Retusot. diversiformis	X	X		X		X	X	X	X						X			X	+	+	+	•	•
Calamosp. hartungiana	X			X			X	X	X	X		X			X			X	+	+			
***Platysaccus* spp.**	X						X	X		X		X	X	X	X	X	X	X					
***Meristocorpus* spp.**	X						X							X	X	X		X				•	
Colpisac.* cf. *granulosus	X										X	X	X	X	X	X	X	X	+	+	+		•
***Brazilea* spp.**	X					X	X	X	X	X		X	X	X				X					
***Granulatisporites* spp.**		X		X		X	X	X	X	X		X	X	X	X		X						
***Alisporites* spp.**			X				X	X		X	X	X	X	X	X	X	X	X				•	•
Cannanoropollis janakii			X				X					X	X			X		X	+	+	+	•	•
***Barakarites* spp.**			X						X							X		X					
***Converruosisporites* spp.**				X		X	X	X	X	X			X	X	X	X	X	X					
***Cristatisporites* spp.**	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X						
***Cyclogranisporites* spp.**	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					•	•
***Cannanoropollis* spp.**	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X						
Fungi indet.	X	X	X	X	X	X	X	X	X	X				X	X		X						
***Vallatisporites* spp.**	X	X	X	X		X	X	X	X	X	X	X	X				X						
***Limitisporites* spp.**	X		X				X	X	X	X		X	X	X	X	X						•	•
***Potonieisporites* spp.**	X		X			X	X	X	X	X		X	X		X	X							
***Crucisaccites* spp.**	X		X			X										X						•	
Scheuringipol. ovatus	X												X		X	X				+	+		•
***Divarisaccus* spp.**	X															X							
***Plicatipollenites* spp.**			X			X		X		X		X	X			X							
Caheniasac.* cf. *ovatus			X										X			X			+	+	+	•	•
***Verrucosiporites* spp.**	X	X	X	X	X	X	X	X	X	X		X	X	X	X								
***Laevigatosporites* spp.**	X		X	X		X	X		X	X	X		X	X	X								
***Grossusporites* spp.**	X	X	X		X		X	X	X	X			X	X	X								
***Apiculatisporis* spp.**	X	X	X		X		X	X	X	X			X		X								
***Brevitriletes* spp.**		X	X	X		X	X	X	X	X			X	X	X								
***Botryococcus* spp.**		X	X	X	X					X	X				X							•	
***Kraeuselisporites* spp.**	X	X	X			X	X	X	X	X		X	X	X									
***Anapiculatisporites* spp.**	X	X		X	X		X		X	X				X									

(*continued*)

Table 1. (*Continued*)

	La Deheza Formation																					Andap. Fm.	
Species/PB SJ*	672	682	658	674B	674T	677	676	663	664	666	678	668	679	680	681	669	670	671	Biozones			Facies association I	Facies association VII
Palynological assemblages			1					2						3									
Facies associations	II		I	IV		V			VI	IX	IX								DM	FS	LW		
Leiotriletes virkkii	X						X			X				X					+	+	+	•	•
Lundblad. riobonitensis	X		X					X	X	X			X						+	+	+	•	•
***Apiculatasporites* spp.**			X			X	X	X	X	X			X										•
Lundbladisp. brasiliensis	X							X		X			X						+	+	+	•	•
Vallatisporites arcuatus	X	X	X	X		X		X	X	X	X								+	+	+	•	•
Cristatisporites stellatus	X	X	X	X	X	X			X	X									+	+			
Cristatisporites rolleri	X	X	X	X						X									+	+		•	
Cristatisp. inconstans	X		X				X			X									+	+		•	
Leiotriletes* cf. *corius	X			X				X		X									+	+		•	
Plicatipoll.malabarensis	X						X	X	X	X									+	+	+	•	
Granu. austroamericanus			X		X			X	X	X									+	+	+	•	
***Spelaeotriletes* spp.**	X	X	X		X	X	X	X	X														
Grossus. micrograulatus	X		X				X	X	X										+	+	+		
Cristatisp. longispinosus	X		X						X										+	+	+	•	
Cristatisporites scabiosus	X		X						X										+	+			
***Convolutispora* spp.**			X						X														
Vallatisporites russoi	X	X	X	X				X											+	+		•	
Cristatisp. menendezi	X		X					X											+	+			
***Circumplicatipollis* sp.**	X		X					X														•	
Brevitriletes levis		X		X			X	X	X	X									+	+	+	•	•
***Lophotriletes* spp.**		X		X			X	X	X	X													
Brevitriletes cornutus	X						X	X											+	+			
***Apiculiretusispora* spp.**		X							X	X													
Brevitriletes parmatus		X				X	X	X											+	+	+		
Dibolisp.* cf. *disfacies					X			X	X										+	+		•	
***Dibolisporites* sp.**					X			X	X														
Retusotriletes simplex					X		X												+	+	+		
Cristat. chacoparanaensis	X		X																+	+	+	•	
Cristatisp.* cf. *spinosus	X		X																+	+			
Caheniasaccites densus	X		X																+	+	+	•	
Apiculatisp. variornatus					X														+	+			
Kraeuselisp. apiculatus						X		X		X										+			
Spelaeotriletes ybertii							X	X	X	X									+	+		•	
***Portalites* spp.**							X																
Horridit. uruguaiensis							X												+	+	+	•	
***Densosporites* spp.**								X	X	X													
Converruosisp.confluens								X	X	X									+	+	+		•
***Michrystridium?* spp.**								X	X														
Kraeuselisp. sanluisensis									X											+			
Anapiculat. tereteangulus						X	X	X	X	X			X		X					+		•	
Cannanoropollis mehtae						X						X	X						+	+	+		•
***Pteruchipollenites* spp.**							X	X		X	X	X	X	X	X	X	X					•	•
Horriditriletes ramosus							X	X	X						X					+	+	•	
***Horriditriletes* spp.**							X	X	X				X										•

(*continued*)

Table 1. (*Continued*)

	La Deheza Formation																					**Andap. Fm.**	
Species/PB SJ*	672	682	658	674B	674T	677	676	663	664	666	678	668	679	680	681	669	670	671	Biozones			Facies association I	Facies association VII
Palynological assemblages			1					2						3									
Facies associations	II		I	IV		V			VI	IX	IX								DM	FS	LW		
Pteruchipol. gracilis							X	X							X	X			+	+	+		•
***Protohaploxypinus* spp.**							X				X	X	X	X	X	X	X	X					•
Vittatina subsaccata							X				X			X		X	X	X		+	+		•
Calamospora breviradiata								X				X	X		X					+	+	•	•
***Minutosaccus* spp.**								X						X									
Falcisporites similis									X		X		X		X	X	X			+	+		•
***Dictyotriletes* spp.**									X				X										
Alisporites australis										X			X			X		X		+	+		•
Latusip. quadrisaccatus											X	X	X	X	X	X	X	X		+	+		•
***Scheuringipollenites* sp.**											X	X	X	X	X	X	X	X					
***Striatopodocarpites* spp.**											X	X	X	X	X	X	X	X					
***Vittatina* spp.**											X	X	X	X	X	X	X	X					•
Barakarites rotatus											X	X	X		X	X	X	X	+	+	+	•	•
***Lueckisporites* spp.**											X		X		X	X	X	X					•
Vittatina costabilis											X		X		X	X	X	X		+	+		•
Protohapl. goraiensis											X		X		X	X		X		+	+		•
Scheuringip. medius											X				X	X		X	+	+	+		•
***Hamiapollenites* spp.**											X		X	X	X	X	X						•
Lueckisporites* cf. *balmei											X		X			X					+		
Protohaploxyp. amplus											X		X			X			+	+	+		•
Protohapl. microcorpus											X					X				+	+		•
***Cycadopites* sp.**												X	X	X	X	X	X	X					
***Klausipollenites* spp.**												X	X	X	X	X	X	X					
***Mabuitasaccites* sp.**												X	X	X	X	X	X	X					
***Vitreisporites* spp.**												X	X		X	X	X	X					
***Pakhapites* spp.**												X		X	X	X	X	X					
Illinites unicus												X	X	X	X	X	X			+	+	•	•
Lueckisp.* cf. *virkkiae												X			X	X					+		
Pakhapites fusus												X	X			X				+	+		•
Protohapl.* cf.*bharadwajii												X	X							+	+	•	
Striatoab.* cf.*multistriatus												X								+	+		
Hamiapoll. ruditaeniatus													X	X		X		X		+	+		•
Caheniasaccites flavatus													X	X		X			+	+	+	•	•
Protohapl.*cf.*suchonensis													X		X	X							
***Striatoabieites* spp.**													X	X	X								
Limitisporites* cf. *rectus													X						+	+	+	•	•
Vittatina fasciolata													X							+	+		•
***Weylandites* spp.**															X	X	X	X					
***Tuberisaccites* sp.**															X	X							
***Accinctisporites* sp.**															X								
Weylandites magmus																X	X	X		+	+		•
***Crutaesporites* sp.**																X							
Pakhapites ovatus																X				+	+		•
Scheuringipoll. maximus																X				+	+		
Weylandites lucifer																X					+		•

*PB SJ acronym collection of 'Colección del Instituto de Ciencias Naturales, Universidad Nacional de San Juan'

Table 2. Composition (in %) of the palynofloral elements recorded in the La Deheza Formation.

Palynological assemblages	1					2					3							
Facies association	II		I	IV		V			VI	IX	IX							
Universidad Nacional de San Juan (UNSJ)	672	682	658	674B	674T	677	676	663	664	666	678	668	679	680	681	669	670	671
Monolete spores	0.1	0	0.4	0.5	0.7	0.5	0.3	0	0.1	0.4	2.0	0	0.4	1.4	0.4	0	0	0
Trilete spores	92.9	95.5	83.8	94.0	94.0	90	93.3	80.2	82.3	88.5	42.0	54.0	41.8	54.5	51.6	2.3	18.6	10.9
Monosaccate smooth pollen grains	4.6	1.5	6.8	2.5	0.7	6	2.8	2.7	1.8	4.7	10.0	17.2	17.6	4.1	8.6	37.4	6.8	8.1
Monosaccate striate pollen grains	0.1	0	0	0	0	0	0	0	0	0	0	0.8	1.09	0.8	1.8	10.8	5.0	5.0
Bisaccate smooth pollen grains	0.8	0	0.6	0	0	0	0.9	1.1	0.3	3.6	17.0	13.6	22.9	21.1	15.1	16.5	18.2	19.4
Bisaccate striate pollen grains	0	0	0	0	0	0	0.3	0	0	0	16.0	6.4	10.5	9.9	13.3	28.7	23.2	17.8
Polyplicate and colpate pollen grains	0	0	0	0	0	0	0.3	0	0	0	6.0	4.4	4.0	5.8	8.9	4.4	27.3	36.9
Fungus	1.3	1.0	6.2	2.0	0.7	3	1.5	12.2	12.3	0.8	0	0	0	0.5	0.2	0	0.9	0
Algae	0.3	2.0	2.1	1.0	4.0	0.5	0.7	2.9	2.6	2.0	7.0	3.6	1.6	1.9	0.2	0	0	1.9
Acritarchs	0	0	0	0	0	0	0	0.9	0.8	0	0	0	0	0	0	0	0	0
TOTAL	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

SJ 678, 668, 680, 681, 669, 670 and 671 (Figure 2). Although palynomorphs are poorly preserved, the diversity of bisaccate smooth, bisaccate striate and plicate pollen grain genera is high, while spore genera diversity is low. At the generic level, only a few specimens of each taxon are identified, except for levels PBSJ 680 and 669. Assemblage 3 is characterised by *Barakarites rotatus* (Plate 2, figure 24), *Caheniasaccites densus* (Plate 2, figure 20), *Latusipollenites quadrisaccatus* (Plate 3, figure 6), *Mabuitasaccites* sp. (Plate 3, figure 9), *Klausipollenites* sp. (Plate 4, figure 6), *Scheuringipollenites medius* (Plate 4, figure 11), *Vitreisporites* spp. (Plate 4, figures 12–13), *Hamiapollenites ruditaeniatus* (Plate 4, figures 20–21), *Illinites unicus* (Plate 4, figures 14, 18), *Lueckisporites* sp. cf. *L.balmei* (Plate 5, figure 1), *L.* sp. cf. *L. virkkiae* (Plate 4, figure 15), *Protohaploxypinus goraiensis* (Plate 5, figures 5, 7), *P. amplus* (Plate 5, figure 2), *P. microcorpus* (Plate 5, figure 3), *P.* sp. cf. *P. bharadwajii* (Plate 5, figures 10–11), *P.* sp. cf. *P. suchonensis* (Plate 5, figure 9), *Striatopodocarpites* sp. (Plate 5, figure 7), *Vittatina costabilis* (Plate 5, figure 14), *Weylandites* spp., and *Pakhapites fusus* (Plate 5, figure 17). Two conspicuous palynomorph groups can be distinguished in Assemblage 3, with 50-m separation in the column: the lower group includes levels PBSJ 678, 668, 680 and 681, whereas the upper group includes levels PBSJ 669, 670 and 671 (Figure 2). Microfloras of the lower group are mostly characterised by trilete spores (40–55%). Bisaccate smooth pollen grains (13.6–22.9%), bisaccate striate pollen grains (6.4–16%), monosaccatte pollen grains (4.1–17.6%), plicate/colpate pollen grains (4–8.9%) and algae (0.2–7%) complete the association. In contrast, the upper group presents a lower proportion of trilete spores (2.3–18.6%). The main components in the latter group are bisaccate striate pollen grains (17.8–28.7%), bisaccate smooth pollen grains (16.5–19.4%), plicate/colpate pollen grains (4.4–36.9%), monosaccate pollen grains (6.8–37.4%) and monosaccate striate pollen grains (5–10.8%) (Table 2).

There was no significant variation in the genus and species composition between these two groups, indicating that both belong to the same microfloristic assemblage (Assemblage 3).

4.2. *Multivariate statistical analysis*

Results derived from the cluster analysis performed using the data presented herein revealed the presence of the three identified assemblages, clustered into two main groups (Figure 4). One of the main branches of the resulting cluster closely relates Assemblage 1 and 2 because of their similar generic composition. However, they can be separated on the basis of their percentile composition. On the other hand, Assemblage 3 is displayed on a separate branch of the cluster, reflecting its different microfloristic composition.

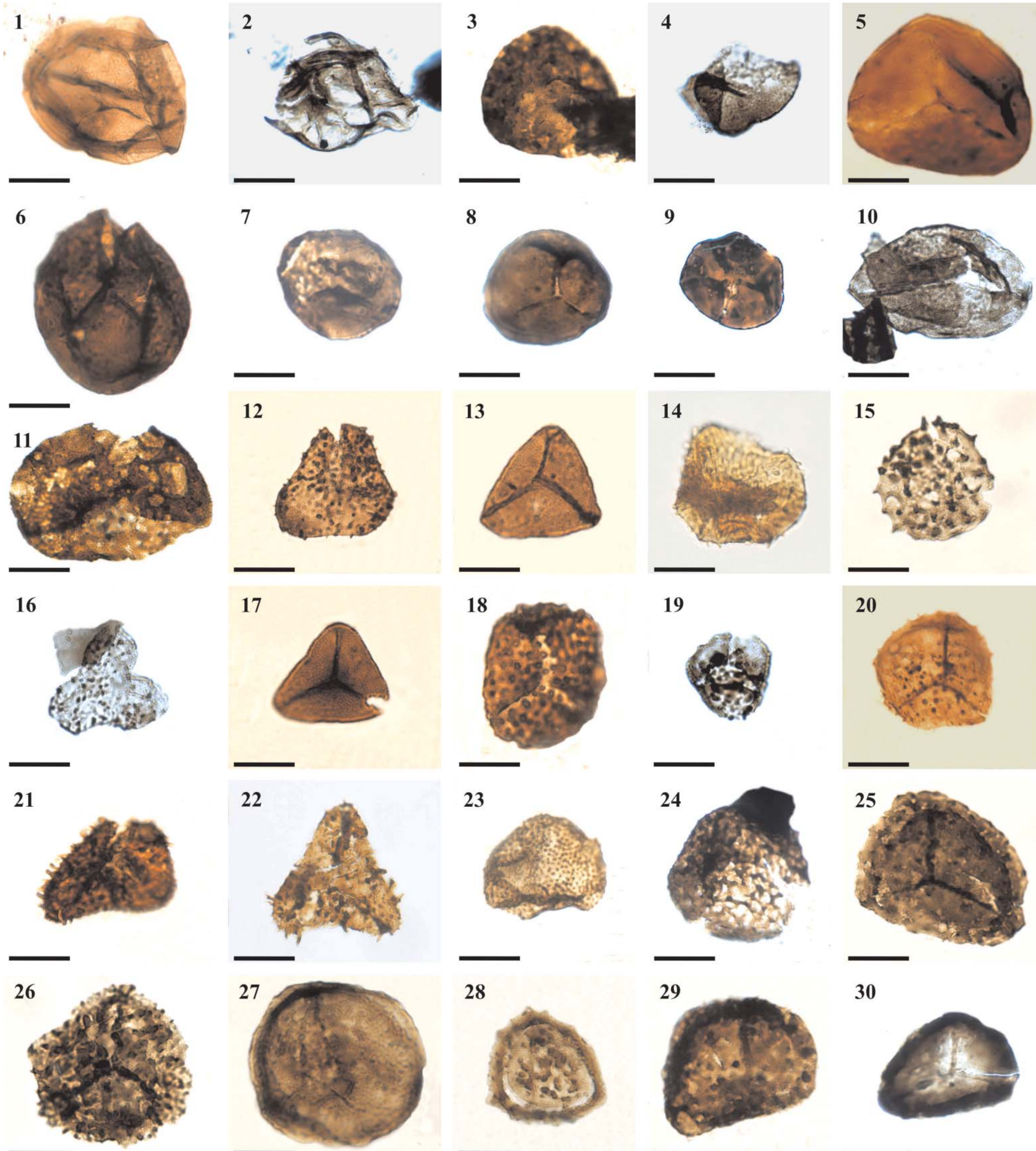

Plate 1. Selected spores from the La Deheza Formation. The bar on each photomicrograph represents 20 μm. figure 1. *Calamospora hartungiana*, PB SJ 663(9) H44/4. figure 2. *Calamospora breviradiata*, PB SJ 668(5) T62/3. figure 3. *Leiotriletes* sp. cf. *L. corius*, PB SJ 672(2) C41/2. figure 4. *Leiotriletes directus*, PS SJ 677(9) D53/0. figure 5. *Leiotriletes virkkii*, PB SJ 663(5) Z39/0. figure 6. *Punctatisporites* sp. cf. *P. gretensis*, PB SJ 663(5) M50/3. figure 7. *Retusotriletes diversiformis*, PB SJ 664(4) M37/0. figure 8. *Retusotriletes simplex*, PB SJ 663(8) Q51/3. figure 9. *Retusotriletes* sp., PB SJ 674T(3) B51/0. figure 10. *Cyclogranisporites* sp., PB SJ 663(8) X25/3. figure 11. *Apiculatasporites* sp., PB SJ 676(4) N53/0. figure 12. *Anapiculatisporites tereteangulus*, PB SJ 663(6) K50/3. figure 13. *Granulatisporites austroamericanus*, PB SJ 663(2)Y62/2. figure 14. *Apiculatisporis variornatus*, PB SJ 674T(1) E32/0. figure 15. *Brevitriletes cornutus*, PB SJ 676(3) M61/0. figure 16. *Lophotriletes* sp., PB SJ 676(5) B45/2. figure 17. *Converrucosisporites confluens*, PB SJ 663(2) J35/0. figure 18. *Verrucosisporites* sp., PB SJ 664(5) H51/0. figure 19. *Brevitriletes parmatus*, PB SJ677(9) G40/0. figure 20. *Brevitriletes levis*, PB SJ 663(5) R51/0. figure 21. *Horriditriletes ramosus*, PB SJ 664(5) K38/4. figure 22. *Horriditriletes uruguaiensis*, PB SJ 676(4) M31/0. figure 23. *Dibolisporites* sp. cf. *D. difacies*, PB SJ 663(3) M47/1. figure 24. *Dictyotriletes* sp., PB SJ 664(4) Z52/0. figure 25. *Kraeuselisporites apiculatus*, PB SJ 658(1) D51/0. figure 26. *Kraeuselisporites sanluisensis*, PB SJ 672(4) B46/0. figure 27. *Grossusporites microgranulatus*, PB SJ 663(3) U44/4. figure 28. *Densosporites* sp., PB SJ 663(3) J24/0. figure 29. *Lundbladispora braziliensis*, PB SJ 658(1) L28/2. figure 30. *Lundbladispora riobonitensis*, PB SJ 664(4) R39/4.

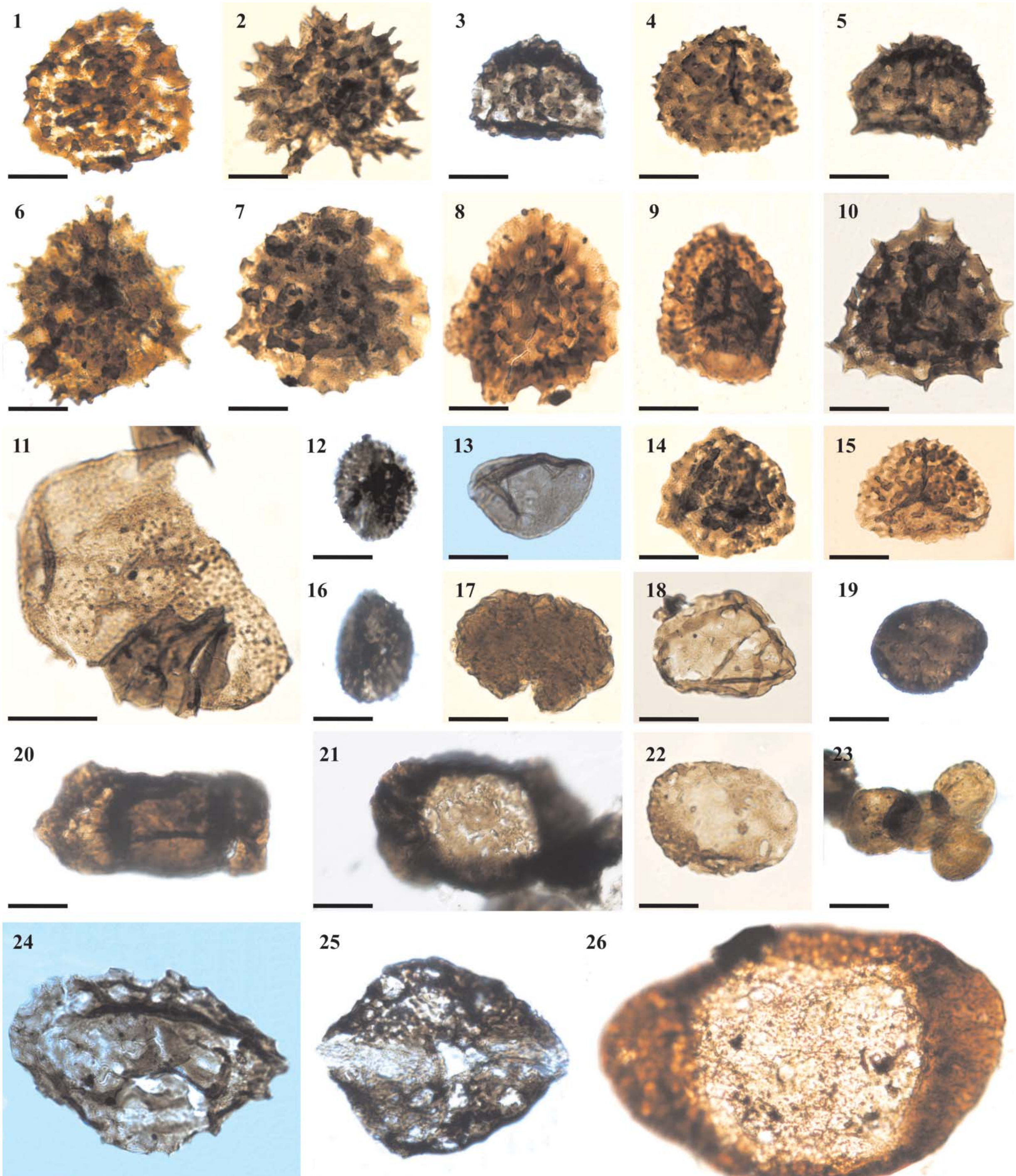

Plate 2. Selected spores and monosaccate pollen grains from the La Deheza Formation. The bar on each photomicrograph represents 20 μm. figure 1. *Cristatisporites chacoparanaensis*, PB SJ 658(3) H45/0. figure 2. *Cristatisporites inconstans*, PB SJ 672(4) B47/3. figure 3. *Cristatisporites menendezi*, PB SJ 672(2) S28/0. figure 4. *Cristatisporites scabiosus*, PB SJ 672(2) X34/4. figure 5. *Cristatisporites* sp. cf. *C. spinosus*, PB SJ 658(1) D35/2. figure 6. *Cristatisporites longispinosus*, PB SJ 672(7) D61/0. figure 7. *Cristatisporites rolleri*, PB SJ 672(2) Z58/0. figure 8. *Vallatisporites arcuatus*, PB SJ 664(3) Y52/0. figure 9. *Vallatisporites* sp., PB SJ 664 (4) E58/0. figure 10. *Cristatisporites stellatus*, PB SJ 658(1) X30/2. figure 11. *Spelaeotriletes ybertii*, PB SJ 676(1) Q48/0. figure 12. *Micrhystridium?* sp., PB SJ 664(4) J57/0. figure 13. *Laevigatosporites* sp., PB SJ 680(1) E50/0. figure 14. *Vallatisporites russoi*, PB SJ 664(3) Y52/3. figure 15. *Cristatisporites* sp., PB SJ 672(4) B48/3. figure 16. *Micrhystridium?* sp., PB SJ 664(4) E44/1. figure 17. *Botryococcus braunii*, PB SJ 658(1) D29/1. figure 18. *Brazilea* sp., PB SJ 668(2) W31/0. figure 19. *Portalites* sp., PB SJ 672(2) J68/0. figure 20. *Caheniasaccites densus*, PB SJ 679(2) Z64/0. figure 21. *Caheniasaccites* sp. cf. *C. ovatus*, PB SJ 669(7) F57/0. figure 22. *Accinctisporites* sp., PB SJ680(10) H60/0. figure 23. Fungus indet., PB SJ 672(7) H60/0. figure 24. *Barakarites rotatus*, PB SJ 668 (5) B51/4. figure 25. *Crucisaccites* sp., PB SJ 669(2) 058/3. figure 26. *Caheniasaccites* sp., PB SJ 669(10) F43/0.

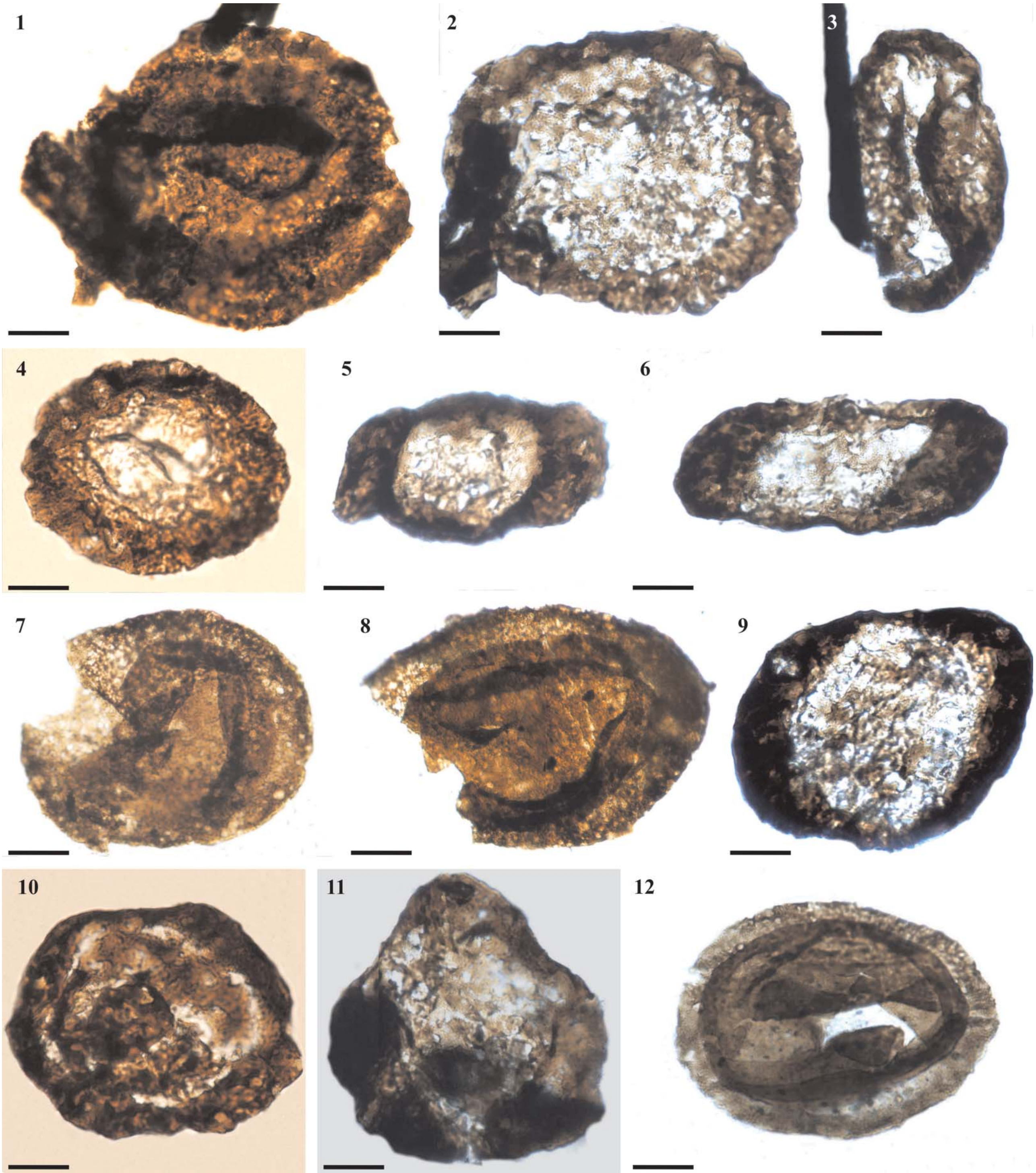

Plate 3. Selected monosaccate pollen grains from the La Deheza Formation. The bar on each photomicrograph represents 20 μm. figure 1. *Circumplicatipollis* sp., PB SJ 672(2) C46/4. figure 2. *Cannanoropollis janakii*, PB SJ 669(6) K21/2. figure 3. *Divarisaccus*? sp., PB SJ 669(6) H21/0. figure 4. *Cannanoropollis mehtae*, PB SJ 669(12) Y58/3. figure 5. *Caheniasaccites flavatus*, PB SJ 669(7) E50/00. figure 6. *Latusipollenites quadrisaccatus*, PB SJ 669(6) J26/1. figure 7. *Potonieisporites* sp., PB SJ658(1) H53/3. figure 8. *Meristocorpus* sp., PB SJ 658(3) J45/1. figure 9. *Mabuitasaccites* sp., PB SJ 669(2) H47/2. figure 10. *Tuberisaccites* sp., PB SJ 669(12) F33/3. figure 11. *Crustaesporites* sp., PB SJ 669(7) V65/0. figure 12. *Plicatipollenites malabarensis*, PB SJ 663(8) Q41/1.

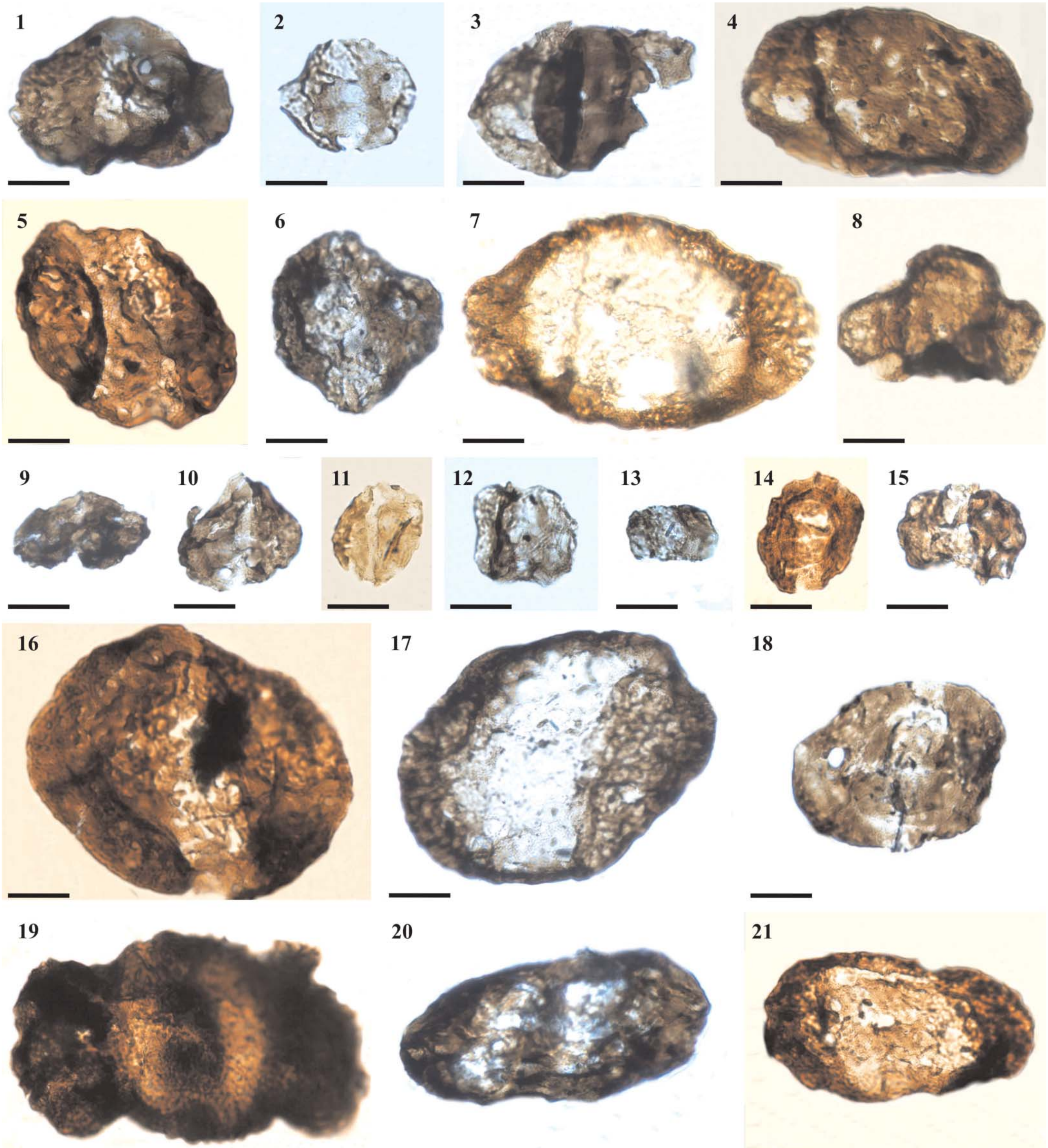

Plate 4. Selected bisaccate smooth and bisaccate striate pollen grains from the La Deheza Formation. The bar on each photomicrograph represents 20 μm. figure 1. *Alisporites australis*, PB SJ 669(4) W51/0. figure 2. *Alisporites similis*, PB SJ 680(9) Q60/0. figure 3. *Limitisporites* sp. cf. *L. rectus*, PB SJ 680(8) T60/0. figure 4. *Limitisporites* sp., PB SJ 681(4) O56/0. figure 5. *Colpisaccites* sp. cf. *C. granulosus*, PB SJ 669(7) A62/4. figure 6. *Klausipollenites* sp., PB SJ 669(2) Q55/4. figure 7. *Pteruchipollenites gracilis*, PB SJ 669(6) C52/1. figure 8. *Minutosaccus* sp., PB SJ 680(2) M52/0. figure 9. *Platysaccus* sp., PB SJ 669(5) C45/0. figure 10. *Scheuringipollenites ovatus*, PB SJ 669(6) B39/2. figure 11. *Scheuringipollenites medius*, PB SJ 678(5) U60/0. figure 12. *Vitreisporites* sp., PB SJ680(3) B53/3. figure 13. *Vitreisporites* sp., PB SJ680(8) A48/0. figure 14. *Illinites unicus*, PB SJ 669(6) J22/1. figure 15. *Lueckisporites* sp. cf. *L. virkkiae*, PB SJ 669(2) E59/2. figure 16. *Scheuringipollenites maximus*, PB SJ 669(5) X50/4. figure 17. *Pteruchipollenites* sp., PB SJ 669(6) S23/2. figure 18. *Illinites unicus*, PB SJ 669(6) J22/1. figure 19. *Hamiapollenites*, sp. PB SJ 669(11) P36/4. figure 20. *Hamiapollenites ruditaeniatus*, PB SJ 669(6) G47/1. figure 21. *Hamiapollenites ruditaeniatus*, PB SJ 669(10) N65/0.

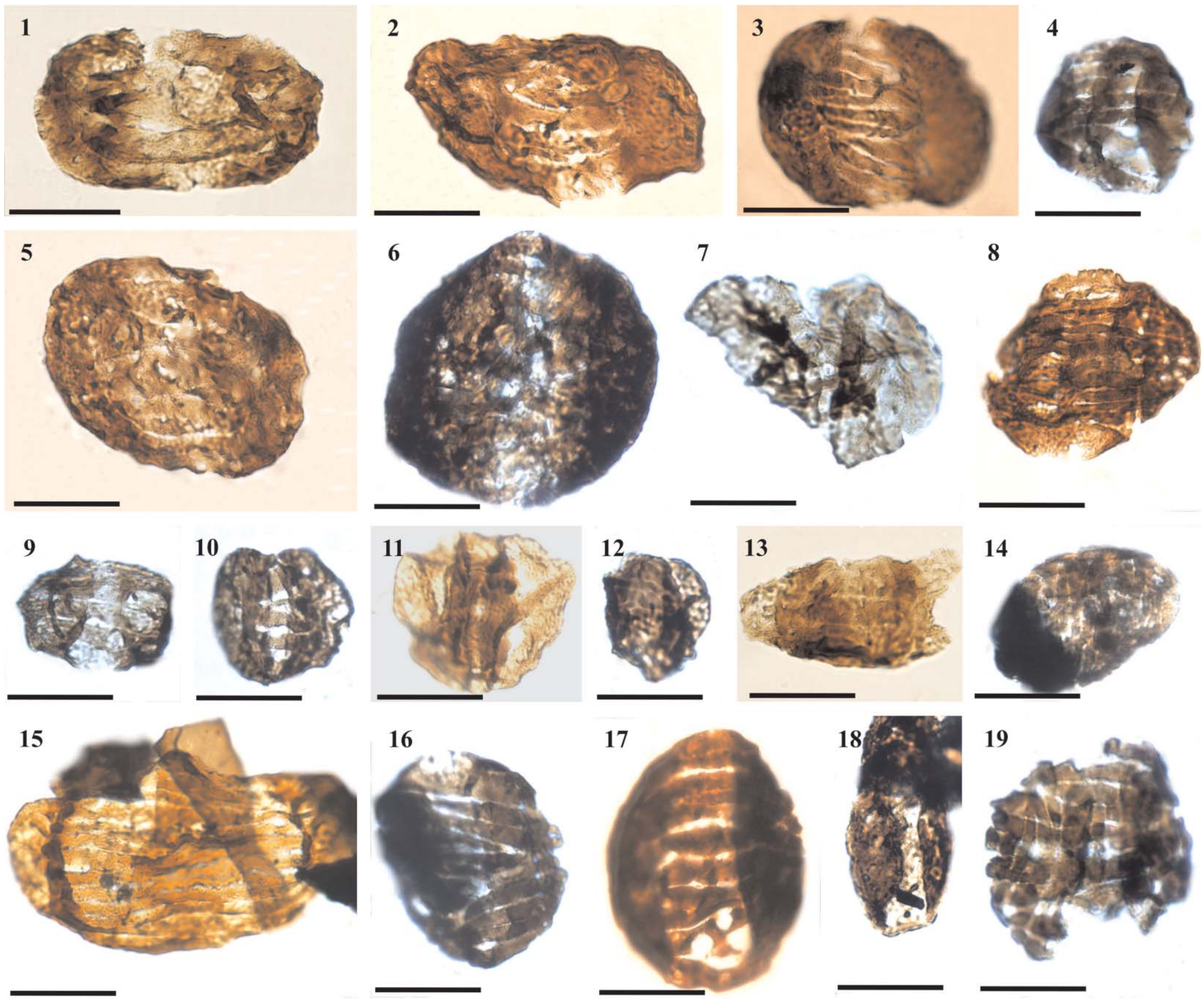

Plate 5. Selected striate pollen grains from the La Deheza Formation. The bar on each photomicrograph represents 20 μm. figure 1. *Lueckisporites* sp. cf. *L. balmei*, PB SJ 678(4) R37/0. figure 2. *Protohaploxypinus amplus*, PB SJ 669(9) W54/2. figure 3. *Protohaploxypinus microcorpus*, PB SJ 669(7) B48/2. figure 4. *Vittatina costabilis*, S54/3. figure 5. *Protohaploxypinus goraiensis*, PB SJ 669(10) X36/2. figure 6. *Protohaploxypinus goraiensis*, PB SJ 669(2) T51/0. figure 7. *Striatopodocarpites* sp., PB SJ 680(8) Q40/2. figure 8. *Vittatina fasciolata*, PB SJ 669(12) O38/1. figure 9. *Protohaploxypinus* sp. cf. *P. suchonensis*, PB SJ 669(2) M62/2. figure 10. *Protohaploxypinus* sp. cf. *P. bharadwajii*, PB SJ 669(7) V42/4. figure 11. *Protohaploxypinus* sp. cf. *P. bharadwajii*, PB SJ 681(4) C67/0. figure 12. *Striatabieites* sp., PB SJ 681(6) D39/3. figure 13. *Striatabieites multistriatus*, PB SJ 678(3) B34/4. figure 14. *Weylandites lucifer*, PB SJ 669(2) E42/4. figure 15. *Vittatina subsaccata*, PB SJ 676(4) 041/2. figure 16. *Pakhapites ovatus*, PB SJ 669(4) B58/4. figure 17. *Pakhapites fusus*, PB SJ 669(6) W47/0. figure 18. *Cycadopites* sp., PB SJ 669(6) Y51/3. figure 19. *Weylandites magmus*, PB SJ 669(7) G47/0.

4.3. Biostratigraphy

The comparison of the microfloristic assemblages from La Deheza Formation with the biozonation scheme known for central western Argentine basins (Paganzo, Río Blanco, Calingasta Uspallata and San Rafael, *sensu* Césari and Gutiérrez 2001, and subsequent modifications – see the references in Table 1) suggests that Assemblages 1 and 2 can be correlated with the *Raistrickia densa–Convolutispora muriornata* (DM) and the *Pakhapites fusus–Vittatina subsaccata* (FS) biozones, respectively, indicating a Pennsylvanian–early Cisuralian age for its stratigraphic interval. Both assemblages share several species such as *Cristatisporites stellatus*, *Brevitriletes cornutus*, *B. levis*, *Cristatisporites menendezi*, *C. rolleri*, *Granulatisporites austroamericanus*, *Lundbladispora riobonitensis* and *Vallatisporites arcuatus*. However, the occurrence of *Converrucosisporites confluens*, *Vittatina subsaccata*, *Kraeuselisporites sanluisensis*,

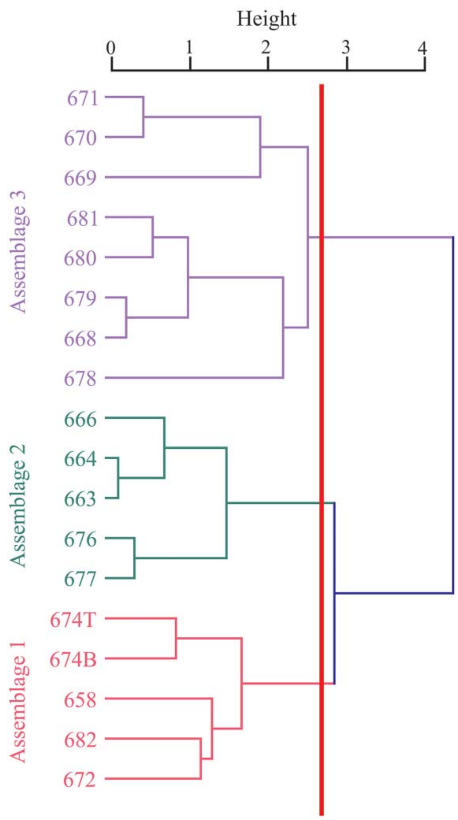

Figure 4. Cluster analysis of palynological levels. Similarity line in red.

Anapiculatisporites teretangulus, *Alisporites australis*, *Calamospora breviradiata*, *Horriditriletes ramosus* and *A. similis*, present in Assemblage 2, supports its attribution to the *Pakhapites fusus–Vittatina subsaccata* (FS) biozone (Figure 2; Table 1). Also, the absence of characteristic species of FS biozone (*Calamospora breviradiata*, *Horriditriletes ramosus*, *Kraeuselisporites apiculatus*, *K. sanluisensis*, *Latusipollenites quadrisaccatus*, *Alisporites australis*, *Vittatina* spp., etc.) and its associations' facies context (glacial–postglacial event with dropstones; see Correa & Gutiérrez 2014) allows us to assign a Pennsylvanian age for Assemblage 1. The specific and generic qualitative and quantitative composition of microflora of Assemblage 2 shows a clear equivalence with the microflora from facies association I of the Andapaico Formation (Table 1).

On other hand, Assemblage 3 could be correlated to the FS and *Lueckisporites–Weylandites* (LW) biozones (Table 1), based on the presence of *Barakarites rotatus*, *Caheniasaccites flavatus*, *Latusipollenites quadrisaccatus*, *Scheuringipollenites medius*, *Protohaploxypinus amplus*, *Striatabieites* sp. cf. *S. multistriatus*, *Vittatina costabilis*, *V. fasciolata*, *Weylandites magmus*, *Pakhapites fusus* and *P. ovatus*, but the presence of *Hamiapollenites ruditaeniatus*, *Lueckisporites* sp. cf. *L. virkkiae*, *L.* sp. cf. *L. balmei*, *Protohaploxypinus microcorpus* and *Weylandites lucifer* indicates the middle–late Cisularian age of the LW biozone. Assemblage 3 could be correlated with the VII facies association of the Andapaico Formation (Table 1).

5. Conclusions

Eighteen levels were studied and 116 palynomorph species were identified. These are the first records of Permian microfloristic associations from La Deheza Formation, Paganzo Basin, San Juan Province. The vertical distribution of species allowed the recognition of three palynological assemblages, also supported by a multivariate statistical analysis. Assemblage 1 is characterised by the restricted occurrence of *Cristatisporites chacoparanaensis*, *C.* sp. cf. *C. sinousus*, *Cahenasaccites densus* and *Apiculatisporis variornatus*. This association is dominated by trilete spores (84%) mainly of *Cristatisporites* and *Punctatisporites* genera and can be referred to the *Raistrickia densa–Convolutispora muriornata* (DM) biozone. Assemblage 2 presents several exclusive species (e.g., *Converrucosisporites confluens*, *Kraeuselisporites sanluisensis*, *K. apiculatus*, *Spelaeotriletes ybertii*, *Horriditriletes uruguaiensis* and *Micrhystridium*? spp.) along with species shared with Assemblage 1 (*Anapiculatisporites tereteangulus*, *Calamospora breviradiata*, *Granulatisporites austroamericanus*, *Horriditriletes ramosus*, *Cannanaropollis mehtae*, *Plicatipollenites malabarensis*, *Alisporites australis*, *A. similis*, *Pteruchipollenites gracilis*, etc.). Although the composition of Assemblage 1 is similar to that of Assemblage 2 (reflected also in the cluster analysis), the increased proportion of pollen grains and the occurrence of *Minutosaccus*, *Protohaploxypinus* and *Vittatina* in this latter assemblage suggests they are different associations. Based on its species composition, Assemblage 2 can be referred to the *Pakhapites fusus–Vittatina subsaccata* (FS) biozone and, therefore, an early Cisuralian age is inferred. Even though Assemblage 3 is characterised by a dominance of trilete spores (40–55%), other groups such as bisaccate smooth, bisaccate striate and plicate pollen grains show an increase and diversification at both generic and specific levels. *Klausipollenites* spp., *Barakarites rotatus*, *Caheniasaccites densus*, *Latusipollenites quadrisaccatus*, *Scheuringipollenites medius*, *Vitreisporites* spp., *Lueckisporites* sp. cf. *L. balmei*, *L.* sp. cf. *L. virkkiae*, *Protohaploxypinus goraiensis*, *P. amplus*, *P. microcorpus*, *P.* sp. cf. *P. bharadwajii*, *P.* sp. cf. *P. suchonensis*, *Striatopodocarpites* spp., *Hamiapollenites ruditaeniatus*, *Illinites unicus*, *Mabuitasaccites* sp., *Pakhapites fusus* and *Weylandites* spp. are recorded for the first time. This association can be referred to the *Lueckisporites–Weylandites* (LW) biozone.

In summary, the biostratigraphical correlation between Assemblages 1 and 2 with the scheme proposed by Césari & Gutiérrez (2001) suggests a Pennsylvanian–early Cisularian age for the basal and middle sections of La Deheza Formation, and a middle–late Cisularian age based on the record of Assemblage 3 at the top of the sequence.

In addition, new information is incorporated (Table 1) into the central-western Argentine basins with the inclusion of the species *Falcisporites similis* for the FS biozone and *Protohaploxypinus* sp. cf. *P. bharadwajii* for the LW biozone.

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Author biographies

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Appendix 1. List of identified species and illustration references

Trilete spores

Calamospora hartungiana Schopf in Schopf, Wilson & Bentall 1944 (Plate 1, figure 1)
Calamospora breviradiata Kosanke 1950 (Plate 1, figure 2)
Calamospora spp. (not illustrated)
Leiotriletes sp. cf. *L. corius* Kar & Bose 1967 (Plate 1, figure 3)
Leiotriletes directus Balme & Hennelly 1956 (Plate 1, figure 4)
Leiotriletes virkkii Tiwari 1965 (Plate 1, figure 5)
Leiotriletes spp. (not illustrated)
Punctatisporites sp. cf. *P. gretensis* Balme & Hennelly 1956 (Plate 1, figure 6)
Punctatisporites spp. (not illustrated)
Retusotriletes diversiformis (Balme & Hennelly) Balme & Playford 1967 (Plate 1, figure 7)
Retusotriletes simplex Naumova 1953 (Plate 1, figure 8)
Retusotriletes sp. (Plate 1, figure 9)

Apiculated trilete spores

Anapiculatisporites tereteangulus (Balme & Hennelly) Playford & Dino 2002 (Plate 1, figure 12)
Apiculatasporites sp. (Plate 1, figure 11)
Apiculatisporis variornatus Di Pasquo, Azcuy & Souza 2003 (Plate 1, figure 14)
Apiculatisporis spp. (not illustrated)
Apiculiretusispora spp. (not illustrated)
Brevitriletes cornutus (Balme & Hennelly) Backhouse 1991 (Plate 1, figure 15)
Brevitriletes levis (Balme & Hennelly) Bharadwaj & Srivastava 1969 (Plate 1, figure 20)
Brevitriletes parmatus (Balme & Hennelly) Backhouse 1991 (Plate 1, figure 19)
Brevitriletes spp. (not illustrated)
Converrucosisporites confluens (Archangelsky & Gamerro) Playford & Dino 2002 (Plate 1, figure 17)
Converrucosisporites spp. (not illustrated)
Convolutispora spp. (not illustrated)
Cyclogranisporites sp. (Plate 1, figure 10)
Dibolisporites sp. cf. *D. difacies* Jones & Truswell 1992 (Plate 1, figure 23)
Dibolisporites sp. (not illustrated)
Dictyotriletes sp. (Plate 1, figure 24)
Granulatisporites austroamericanus Archangelsky & Gamerro 1979 (Plate 1, figure 13)
Granulatisporites spp. (not illustrated)
Horriditriletes ramosus (Balme & Hennelly) Bharadwaj & Salujha 1964 (Plate 1, figure 21)
Horriditriletes uruguaiensis (Marques Toigo) Archangelsky & Gamerro 1979 (Plate 1, figure 22)
Horriditriletes spp. (not illustrated)
Lophotriletes sp. (Plate 1, figure 16)
Verrucosisporites sp. (Plate 1, figure 18)

Cingulated trilete spores

Cristatisporites chacoparanaensis Ottone, 1989 (Plate 2, figure 1)
Cristatisporites inconstans Archangelsky & Gamerro 1979 (Plate 2, figure 2)
Cristatisporites longispinosus Menendez 1971 (Plate 2, figure 6)
Cristatisporites menendezi (Menendez & Azcuy) Playford 1978 (Plate 2, figure 3)
Cristatisporites rolleri Ottone 1989 (Plate 2, figure 7)
Cristatisporites scabiosus Menendez 1965 (Plate 2, figure 4)
Cristatisporites sp. cf. *C. spinosus* (Menendez & Azcuy) Playford 1978 (Plate 2, figure 5)
Cristatisporites stellatus (Azcuy) Gutierrez & Limarino 2001 (Plate 2, figure 10)
Cristatisporites sp. (Plate 2, figure 15)
Densosporites sp. (Plate 1, figure 28)
Endosporites sp. (not illustrated)
Grossusporites microgranulatus (Menendez & Azcuy) Perez Loinaze & Cesari 2004 (Plate 1, figure 27)
Grossusporites sp. (not illustrated)
Kraeuselisporites apiculatus Jansonius 1962 (Plate 1, figure 25)
Krauselisporites sanluisensis Menendez 1971 (Plate 1, figure 26)
Krauselisporites spp. (not illustrated)
Lundbladispora brasiliensis (Marques-Toigo & Pons) Marques-Toigo & Picarelli 1985 (Plate 1, figure 29)
Lundlbadispora riobonitensis Marques-Toigo & Picarelli 1985 (Plate 1, figure 30)
Lundbladispora sp. (not illustrated)
Vallatisporites arcuatus (Marques-Toigo) Archangelsky & Gamerro 1979 (Plate 2, figure 8)
Vallatisporites russoi Archangelsky & Gamerro 1979 (Plate 2, figure 14)
Vallatisporites sp. (Plate 2, figure 9)

Camerated trilete spores

Spelaeotriletes ybertii (Marques-Toigo) Playford & Powis 1979 (Plate 2, figure 11)
Spelaeotriletes spp. (not illustrated)

Monolete spores

Laevigatosporites sp. (Plate 2, figure 13)

Algae-Prasynophyta

Botryococcus sp. (Plate 2, figure 17)
Brazilea sp. (Plate 2, figure 18)

Fungii

Portalites sp. (Plate 2, figure 19)
Fungus indet. (Plate 2, figure 23)

Acritarchs

Michrystridium? spp. (Plate. 2, figures 12 and 16)
Comparision. *Micrhystridium* sp. described from the top of the San Gregorio Formation (Beri et al. 2006, p. 242,

figs 4K, 4N) is superficially similar but the specimens from the La Deheza Formation are poorly preserved and did not allow further comparison.

Monosaccate pollen grains

Accinctisporites sp. (Plate 2, figure 22)
Barakarites rotatus (Balme & Hennelly) Bharadwaj & Tiwari 1964 (Plate 2, figure 24)
Barakarites spp. (not illustrated)
Caheniasaccites densus Lele & Karim emend. Gutierrez 1993 (Plate 2, figure 20)
Caheniasaccites flavatus (Bose & Kar) emend. Azcuy & Di Pasquo 2000 (Plate 3, figure 5)
Caheniasaccites sp. cf. *C. ovatus* Lele & Karim emend. Gutierrez 1993 (Plate 2, figure 21)
Caheniasaccites sp. (Plate 2, figure 26)
Cannanoropollis janakii Potonie & Sah 1960 (Plate 3, figure 2)
Cannanoropollis mehtae (Lele) Bose & Maheshwari 1968 (Plate 3, figure 4)
Cannanoropollis spp. (not illustrated)
Circumplicatipollis sp. (Plate 3, figure 1)
Crucisaccites sp. (Plate 2, figure 25)
Divarisaccus? sp. (Plate 3, figure 3)
Latusipollenites quadrisaccatus Marques-Toigo 1974 (Plate 3, figure 6)
Plicatipollenites malabarensis (Potonie & Sah) Foster 1975 (Plate 3, figure 12)
Plicatipollenites spp. (not illustrated)
Potonieisporites sp. (Plate 3, figure 7)
Tuberisaccites sp. (Plate 3, figure 10)
Crustaesporites sp. (Plate 3, figure 11)
Mabuitasaccites sp. (Plate 3, figure 9)
Meristocorpus sp. (Plate 3, figure 8)

Bisaccate smooth pollen grains

Alisporites australis de Jersey 1962 (Plate 4, figure 1)
Alisporites similis (Balme) Balarino 2012 (Plate 4, figure 2)
Alisporites spp. (not illustrated)
Colpisaccites sp. cf. *C. granulosus* Archangelsky & Gamerro 1979 (Plate 4, figure 5)
Klausipollenites sp. (Plate 4, figure 6)
Limitisporites sp. cf. *L. rectus* Leschik 1956 (Plate 4, figure 3)
Limitisporites sp. (Plate 4, figure 4)
Minutosaccus sp. (Plate 4, figure 8)
Platysaccus sp. (Plate 4, figure 9)
Pteruchipollenites gracilis (Segroves) Foster 1979 (Plate 4, figure 7)
Pteruchipollenites sp. (Plate 4, figure 17)
Scheuringipollenites maximus (Hart) Tiwari 1973 (Plate 4, figure 16)
Scheuringipollenites medius (Burjack) Dias-Fabricio 1981 (Plate 4, figure 11)
Scheuringipollenites ovatus (Balme & Hennelly) Foster 1979 (Plate 4, figure 10)
Scheuringipollenites. sp. (not illustrated)
Vitreisporites spp. (Plate 4, figures 12 and 13)

Bisaccate striate pollen grains

Hamiapollenites ruditaeniatus Qu & Wang 1986 (Plate 4, figures 20 and 21)
Hamiapollenites sp. (Plate 4, figure 19)
Illinites unicus Kosanke emend. Jansonius & Hills 1976 (Plate 4, figures 14 and 18)
Lueckisporites sp. cf. *L. virkkiae* Potonie & Klaus 1954 (Plate 4, figure 15)
Lueckisporites sp. cf. *L. balmei* (Tiwari & Vijaya) Gutierrez, Zavattieri, Ezpeleta & Astini 2011 (Plate 5, figure 1)
Lueckisporites spp. (not illustrated)
Protohaploxypinus amplus (Balme and Hennelly) Hart 1964 (Plate 5, figure 2)
Protohaploxypinus goraiensis (Potonie and Lele) Hart 1964 (Plate 5, figures 5 and 6)
Protohaploxypinus microcorpus (Schaarschmidt) Clarke 1965 (Plate 5, figure 3)
Protohaploxypinus sp. cf. *P. suchonensis* (Sedova) Hart 1964 (Plate 5, figure 9)
Protohaploxypinus sp. cf. *P. bharadwajii* Foster 1979 (Plate 5, figures 10 and 12)
Protohaploxypinus spp. (not illustrated)
Striatabieites sp. cf. *S. multistriatus* (Balme and Hennelly) Hart 1964 (Plate 5, figure 13)
Striatabieites sp. (Plate 5, figure 12)
Striatopodocarpites sp. (Plate 5, figure 7)

Plicate pollen grains

Vittatina costabilis Wilson 1962 (Plate 5, figure 4)
Vittatina fasciolata (Balme & Hennelly) Bharadwaj 1962 (Plate 5, figure 8)
Vittatina subsaccata Samoilovich 1953 (Plate 5, figure 15)
Vittatina spp. (not illustrated)
Weylandites lucifer (Bharadwaj & Salujha) Foster 1975 (Plate 5, figure 14)
Weylandites magmus (Bose & Kar) Backhouse 1991 (Plate 5, figure 19)
Weylandites spp. (not illustrated)

Colpate pollen grains

Cycadopites sp. (Plate 5, figure 18)
Pakhapites fusus (Bose & Kar) Menendez 1971 (Plate 5, figure 17)
Pakhapites ovatus (Bose & Kar) Garcia 1996 (Plate 5, figure 16)
Pakhapites spp. (not illustrated)

Appendix 2. Matrix of multivariate analysis. *Laevi (Laevigatosporites); Calam (Calamospora); Anapi (Anapiculatisporites); Apicla (Apiculatasporites); Apicul (Apiculatisporis); Apicu (Apiculiretispora); Brevi (Brevitriletes); Conve (Converrucosisporites); Convo (Convolutispora); Cyclo (Cyclogranisporites); Dibol (Dibolisporites); Dicty (Dictyotriletes); Granu (Granulatisporites); Horri (Horriditriletes); Leio (Leiotriletes); Lopho(Lophotriletes); Punct (Punctatisporites); Retus (Retusotriletes); Verruc (Verrucosisporites); Crista (Cristatisporites); Denso (Densosporites); Endos (Endosporites);Gross (Grossusporites); Kraus (Krauselisporites); Lundb (Lundbladispora); Spela (Spelaeotriletes); Vallat (Vallatisporites); Accin (Accinctisporites); Barak (Barakarites); Cahen (Caheniasaccites); Circm (Circumplicatipollis); Colpi (Colpisaccites); Hamia (Hamiapollenites); Klaus (Klausipollenites); Limit (Limitisporites);Minut (Minutosaccus); Platy (Platysaccus); Scheu (Scheuringipollenites); Striat (Striatabieites); Cruci (Crucisaccites); Latus (Latusipollenites); Mabui (Mabuitasaccites); Meris (Meristocorpus); Canna (Cannanaropollis); Divar (Divarisaccus); Plica (Plicatipollenites); Poto (Potonieisporites); Tuber (Tuberisaccites); Alis (Alisporites); Pteru (Pteruchipollenites); Vtrei (Vitreisporites); Cycad (Cycadopites); Pakha (Pakhapites); Vittat (Vittatina); Crusta (Crutaesporites); Illin (Illinites);Lueck (Lueckisporites); Proto (Protohaploxypinus); Striat (Striatopodocarpites); Weyla (Weylandites); Fungi; Porta (Portalites); Botryo (Botryococcus); Brazil (Brazilea); Micrh (Micrhystridium).*

	Laevi	Calam	Anapi	Apicla	Apicul	Apicu	Brevi	Conve	Convo	Cyclo	Dibol	Dicty	Granu	Horri	Leio	Lopho	Punct	Retus	Verruc	Crista	Denso	Endos	Gross	Kraus	Lundb	Spela	Vallat	Accin	Barak	Cahen	Circm	Colpi
671	0.000	0.038	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.019	0.000	0.038	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.034	0.034	0.000	0.006
670	0.000	0.036	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.014	0.000	0.000	0.009	0.000	0.027	0.000	0.045	0.000	0.000	0.036	0.000	0.000	0.000	0.000	0.009	0.000	0.005	0.000	0.018	0.018	0.000	0.005
669	0.000	0.400	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.001	0.000	0.000	0.000	0.000	0.002	0.000	0.010	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.033	0.124	0.000	0.004
681	0.004	0.289	0.002	0.000	0.002	0.000	0.004	0.007	0.000	0.009	0.000	0.000	0.007	0.002	0.040	0.000	0.109	0.016	0.005	0.012	0.000	0.000	0.004	0.000	0.009	0.000	0.000	0.002	0.012	0.016	0.000	0.014
680	0.140	0.318	0.005	0.000	0.000	0.000	0.005	0.008	0.000	0.019	0.000	0.000	0.016	0.000	0.077	0.000	0.079	0.000	0.005	0.003	0.000	0.000	0.003	0.005	0.000	0.000	0.000	0.000	0.000	0.022	0.000	0.014
679	0.004	0.195	0.007	0.007	0.002	0.000	0.007	0.007	0.000	0.013	0.000	0.002	0.007	0.004	0.044	0.000	0.044	0.007	0.002	0.031	0.000	0.000	0.005	0.004	0.025	0.000	0.005	0.000	0.013	0.056	0.000	0.005
668	0.000	0.224	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.036	0.000	0.000	0.008	0.000	0.084	0.000	0.076	0.020	0.008	0.024	0.000	0.000	0.000	0.004	0.032	0.000	0.024	0.000	0.020	0.032	0.000	0.008
678	0.020	0.050	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.060	0.000	0.000	0.000	0.000	0.06	0.000	0.120	0.000	0.000	0.030	0.000	0.000	0.000	0.000	0.060	0.000	0.040	0.000	0.040	0.000	0.000	0.030
666	0.004	0.068	0.013	0.020	0.001	0.003	0.011	0.012	0.000	0.027	0.000	0.000	0.016	0.000	0.119	0.001	0.208	0.039	0.023	0.123	0.012	0.003	0.016	0.015	0.109	0.005	0.043	0.000	0.000	0.007	0.000	0.000
664	0.001	0.019	0.019	0.016	0.003	0.004	0.026	0.016	0.003	0.033	0.001	0.001	0.010	0.003	0.038	0.003	0.326	0.048	0.028	0.033	0.010	0.015	0.033	0.014	0.083	0.008	0.035	0.000	0.003	0.001	0.000	0.000
663	0.000	0.024	0.018	0.020	0.016	0.000	0.060	0.011	0.000	0.020	0.002	0.000	0.013	0.004	0.069	0.002	0.320	0.029	0.700	0.044	0.004	0.009	0.024	0.020	0.056	0.004	0.024	0.000	0.000	0.002	0.001	0.000
676	0.003	0.037	0.035	0.028	0.013	0.000	0.028	0.005	0.000	0.104	0.000	0.000	0.015	0.008	0.069	0.012	0.251	0.048	0.021	0.187	0.000	0.000	0.004	0.020	0.015	0.016	0.017	0.000	0.000	0.004	0.000	0.000
677	0.005	0.025	0.010	0.005	0.000	0.000	0.020	0.005	0.000	0.055	0.000	0.000	0.015	0.000	0.095	0.000	0.45	0.050	0.015	0.100	0.000	0.000	0.000	0.015	0.010	0.020	0.010	0.000	0.000	0.005	0.000	0.000
674T	0.007	0.027	0.007	0.000	0.007	0.000	0.000	0.000	0.000	0.033	0.007	0.000	0.013	0.000	0.127	0.000	0.267	0.040	0.007	0.207	0.000	0.000	0.087	0.000	0.107	0.007	0.000	0.000	0.000	0.000	0.000	0.000
674B	0.005	0.015	0.005	0.000	0.000	0.000	0.010	0.005	0.000	0.030	0.000	0.000	0.010	0.000	0.045	0.005	0.335	0.020	0.015	0.397	0.000	0.000	0.000	0.000	0.020	0.000	0.030	0.000	0.000	0.005	0.000	0.000
658	0.004	0.006	0.000	0.009	0.002	0.000	0.004	0.000	0.002	0.009	0.000	0.000	0.002	0.000	0.015	0.000	0.157	0.009	0.200	0.570	0.000	0.000	0.002	0.021	0.009	0.009	0.011	0.000	0.002	0.006	0.002	0.000
682	0.000	0.020	0.015	0.000	0.005	0.005	0.015	0.000	0.000	0.010	0.000	0.000	0.010	0.000	0.095	0.010	0.235	0.020	0.005	0.420	0.000	0.000	0.005	0.010	0.03	0.005	0.040	0.000	0.000	0.000	0.000	0.000
672	0.001	0.005	0.003	0.000	0.004	0.000	0.004	0.000	0.000	0.020	0.000	0.000	0.000	0.000	0.019	0.000	0.131	0.003	0.004	0.649	0.000	0.000	0.003	0.026	0.046	0.001	0.013	0.000	0.000	0.006	0.006	0.001

	Hamia	Klaus	Limit	Minut	Platy	Scheu	Striat	Cruci	Latus	Mabui	Meris	Canna	Divar	Plica	Poto	Tuber	Alis	Pteru	Vtrei	Cycad	Pakha	Vitat	Crusta	Illin	Lueck	Proto	Striat	Weyla	Fungi	Porta	Botryo	Brazil	Michr
671	0.072	0.006	0.000	0.000	0.016	0.069	0.000	0.000	0.003	0.047	0.003	0.009	0.000	0.000	0.000	0.000	0.091	0.000	0.006	0.006	0.025	0.263	0.000	0.000	0.009	0.094	0.003	0.075	0.000	0.000	0.000	0.019	0.000
670	0.068	0.009	0.000	0.000	0.005	0.068	0.000	0.000	0.005	0.050	0.000	0.027	0.000	0.000	0.000	0.000	0.082	0.009	0.005	0.014	0.005	0.205	0.000	0.014	0.000	0.132	0.018	0.050	0.009	0.000	0.000	0.000	0.000
669	0.087	0.008	0.002	0.000	0.003	0.027	0.000	0.008	0.065	0.103	0.001	0.098	0.003	0.008	0.023	0.012	0.032	0.085	0.003	0.002	0.001	0.024	0.004	0.015	0.010	0.169	0.005	0.008	0.000	0.000	0.000	0.000	0.000
681	0.005	0.023	0.021	0.000	0.018	0.014	0.014	0.000	0.009	0.016	0.002	0.035	0.000	0.000	0.009	0.004	0.037	0.021	0.004	0.011	0.018	0.049	0.000	0.012	0.007	0.063	0.032	0.012	0.002	0.000	0.002	0.000	0.000
680	0.014	0.019	0.027	0.005	0.014	0.036	0.005	0.000	0.008	0.005	0.003	0.011	0.000	0.000	0.000	0.000	0.066	0.030	0.000	0.014	0.014	0.030	0.000	0.005	0.000	0.060	0.014	0.000	0.005	0.000	0.000	0.019	0.000
679	0.016	0.033	0.069	0.000	0.011	0.018	0.005	0.000	0.013	0.011	0.000	0.085	0.000	0.005	0.004	0.000	0.08	0.007	0.005	0.013	0.020	0.007	0.000	0.002	0.007	0.065	0.009	0.000	0.000	0.000	0.000	0.016	0.000
668	0.000	0.008	0.020	0.000	0.024	0.008	0.008	0.000	0.012	0.008	0.000	0.084	0.000	0.012	0.012	0.000	0.044	0.012	0.012	0.012	0.012	0.020	0.000	0.004	0.008	0.040	0.004	0.000	0.000	0.000	0.000	0.036	0.000
678	0.050	0.000	0.000	0.000	0.000	0.050	0.000	0.000	0.060	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.060	0.030	0.000	0.000	0.000	0.060	0.000	0.000	0.030	0.060	0.020	0.000	0.000	0.000	0.070	0.000	0.000
666	0.000	0.000	0.016	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.027	0.000	0.007	0.007	0.000	0.012	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.000	0.008	0.012	0.000
664	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.011	0.000	0.001	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.123	0.000	0.000	0.026	0.008
663	0.000	0.000	0.002	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.018	0.000	0.002	0.002	0.000	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.122	0.000	0.000	0.029	0.009
676	0.000	0.000	0.003	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.016	0.000	0.003	0.005	0.000	0.003	0.003	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.003	0.000	0.000	0.013	0.001	0.000	0.007	0.000
677	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.000	0.000	0.030	0.000	0.005	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.030	0.000	0.000	0.005	0.000
674T	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.000	0.040	0.000	0.000
674B	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.020	0.000	0.010	0.000	0.000
658	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.043	0.000	0.004	0.006	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.062	0.000	0.021	0.000	0.000
682	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.000	0.020	0.000	0.000
672	0.000	0.000	0.003	0.000	0.003	0.001	0.000	0.004	0.000	0.000	0.001	0.023	0.001	0.003	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.013	0.000	0.000	0.003	0.000

Appendix 3. Distribution (in %) of the genus for palynological levels recorded in the La Deheza Formation. Abbreviations: MS: monolete spores; STS: smooth trilete spores; ATS: apiculate trilete spores; CTS: cingulate-camerate trilete spores; MPGs: monosaccate smooth pollen grains; MPGst: monosaccate striate pollen grains; BPG: bisaccate smooth pollen grains; BSPG: bisaccate striate pollen grains; PCPG: polyplicate-colpate pollen grains; Autoch.: autochthonous; Reworked.

Palynological Assemblages		1										2										3															
Facies association		III				I		V				VI						VII		X		X															
PBSJ		672		682		658		674B		674T		677		676		663		664		666		678		668		679		680		681		669		670		671	
	Genus	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%
ME	*Laevigatisporites*	1	0.1			2	0.4	1	0.5	1	0.7	1	0.5	2	0.3			1	0.1	3	0.4	2	2.0			2	0.4	5	1.4	2	0.4						
STS	*Calamospora*	4	0.5	4	2.0	3	0.6	3	1.5	4	2.7	5	2.5	28	3.7	11	2.4	15	1.9	51	6.8	5	5.0	56	22.4	107	19.5	116	31.8	165	28.9	5	0.4	8	3.6	12	3.8
	Leiotriletes	15	1.9	19	9.5	7	1.5	9	4.5	19	12.7	19	9.5	52	6.9	31	6.9	30	3.8	89	11.9	6	6.0	21	8.4	24	4.4	28	7.7	23	4.0	2	0.2	6	2.7	6	1.9
	Punctatisporites	105	13.1	47	23.5	74	15.7	67	33.5	40	26.7	90	45.0	188	25.1	144	32.0	261	32.6	156	20.8	12	12.0	19	7.6	24	4.4	29	7.9	62	10.9	13	1.0	10	4.5	12	3.8
	Retusotriletes	2	0.3	4	2.0	4	0.9	4	2.0	6	4.0	10	5.0	36	4.8	13	2.9	38	4.8	29	3.9			5	2.0	4	0.7			9	1.6					4	1.3
ATS	*Anapiculatisporites*	2	0.3	3	1.5			1	0.5	1	0.7	2	1.0	26	3.5	8	1.8	15	1.9	10	1.3					4	0.7	2	0.5	1	0.2						
	Apiculatasporites					4	0.9					1	0.5	21	2.8	9	2.0	13	1.6	15	2.0					4	0.7										
	Apiculatisporis	3	0.4	1	0.5	1	0.2			1	0.7			10	1.3	7	1.6	2	0.3	1	0.1					1	0.2			1	0.2						
	Apiculiretusispora			1	0.5													3	0.4	2	0.3																
	Brevitriletes	3	0.4	3	1.5	2	0.4	2	1.0			4	2.0	21	2.8	27	6.0	21	2.6	8	1.1					4	0.7	2	0.5	2	0.4						
	Converrucosisporites							1	0.5			1	0.5	4	0.5	5	1.1	13	1.6	9	1.2					4	0.7	3	0.8	4	0.7	3	0.2	1	0.5	1	0.3
	Convolutispora					1	0.2											2	0.3																		
	Cyclogranisporites	16	2.0	2	1.0	4	0.9	6	3.0	5	3.3	11	5.5	78	10.4	9	2.0	26	3.3	20	2.7	6	6.0	9	3.6	7	1.3	7	1.9	5	0.9	1	0.1	3	1.4		
	Dibolisporites									1	0.7					1	0.2	1	0.1																		
	Dictyotriletes																	1	0.1							1	0.2										
	Granulatisporites			2	1.0	1	0.2	2	1.0	2	1.3	3	1.5	11	1.5	6	1.3	8	1.0	12	1.6			2	0.8	4	0.7	6	1.6	4	0.7			2	0.9		
	Horriditriletes													6	0.8	2	0.4	2	0.3							2	0.4			1	0.2						
	Lophotriletes			2	1.0			1	0.5					9	1.2	1	0.2	2	0.3	1	0.1																
	Verrucosisporites	3	0.4	1	0.5	1	0.2	3	1.5	1	0.7	3	1.5	16	2.1	3	0.7	22	2.8	17	2.3			2	0.8	1	0.2	2	0.5	3	0.5						
CTS	*Cristatisporites*	519	64.9	84	42.0	268	57.0	79	39.5	31	20.7	20	10.0	140	18.7	20	4.4	26	3.3	92	12.3	3	3.0	6	2.4	17	3.1	1	0.3	7	1.2	2	0.2	8	3.6		
	Densosporites															2	0.4	8	1.0	9	1.2																
	Endosporites															4	0.9	12	1.5	2	0.3																
	Grossusporites	2	0.3	1	0.5	1	0.2			13	8.7			3	0.4	11	2.4	26	3.3	12	1.6					3	0.5	1	0.3	2	0.4						
	Krauselisporites	21	2.6	2	1.0	10	2.1					3	1.5	15	2.0	9	2.0	11	1.4	11	1.5			1	0.4	2	0.4	2	0.5								
	Lundbladispora	37	4.6	6	3.0	4	0.9	4	2.0	16	10.7	2	1.0	11	1.5	25	5.6	66	8.3	82	10.9	6	6.0	8	3.2	14	2.5			5	0.9	4	0.3	2	0.9		
	Spelaeotriletes	1	0.1	1	0.5	4	0.9			1	0.7	4	2.0	12	1.6	2	0.4	6	0.8	4	0.5																
	Vallatisporites	10	1.3	8	4.0	5	1.1	6	3.0			2	1.0	13	1.7	11	2.4	28	3.5	32	4.3	4	4.0	6	2.4	3	0.5							1	0.5		.
MPGs	*Accintisporites*																													1	0.2						
	Barakarites					1	0.2											2	0.3			4	4.0	5	2.0	7	1.3			7	1.2	43	3.3	4	1.8	11	3.4
	Caheniasaccites	5	0.6			3	0.6	1	0.5			1	0.5	3	0.4	1	0.2	1	0.1	5	0.7			8	3.2	31	5.6	8	2.2	9	1.6	161	12.4	4	1.8	11	3.4
	Cannanoropollis	18	2.3	3	1.5	20	4.3	4	2.0	1	0.7	6	3.0	12	1.6	8	1.8	9	1.1	20	2.7			21	8.4	47	8.5	4	1.1	20	3.5	127	9.8	6	2.7	3	0.9
	Circumplicatipollis	5	0.6			1	0.2									1	0.2																				
	Crucisaccites	3	0.4			2	0.4					1	0.5																			11	0.8				
	Divarisaccus	1	0.1																													4	0.3				
	Latusipollenites																					6	6.0	3	1.2	7	1.3	3	0.8	5	0.9	84	6.5	1	0.5	1	0.3
	Plicatipollenites	2	0.3			2	0.4					1	0.5	2	0.3	1	0.2	1	0.1	5	0.7			3	1.2	3	0.5					11	0.8				

(*continued*)

Palynological Assemblages		1									
Facies association		III				I		V			
PBSJ		672		682		658		674B		674T	
	Genus	F	%	F	%	F	%	F	%	F	%
	Potonieisporites	3	0.4			3	0.6				
	Tuberisaccites										
MPGst	*Crustaesporites*										
	Mabuitasaccites										
	Meristocorpus	1	0.1								
BPG	*Alisporites*					1	0.2				
	Colpisaccites	1	0.1								
	Klausipollenites										
	Limitisporites	2	0.3			2	0.4				
	Minutosaccus										
	Platysaccus	2	0.3								
	Pteruchipollenites										
	Scheuringipollenites	1	0.1								
	Vtreisporites										
BSPG	*Hamiapollenites*										
	Illinites										
	Lueckisporites										
	Protohaploxypinus										
	Striatoabieites										
	Striatopodocarpites										
PCPG	*Cycadopites*										
	Pakhapites										
	Vitattina										
	Weylandites										
Fungii	Fungii indet.	10	1.3	2	1.0	29	6.2	4	2.0	1	0.7
	Portalites										
Algae	*Botryococcus*			4	2.0	10	2.1	2	1.0	6	4.0
	Brazilea	2	0.3								
Acritarchs	*Michrystridium?*										
Autoch.	**TOTAL**	800	100	200	100	470	100	200	100	150	100
Rework	**Spores**	8	1.0	4	2.0	25	5.3	10	4.8		

Palynological Assemblages		2									
Facies association		VI						VII		X	
PBSJ		677		676		663		664		666	
	Genus	F	%	F	%	F	%	F	%	F	%
	Potonieisporites	3	1.5	4	0.5	1	0.2	1	0.1	5	0.7
	Tuberisaccites										
MPGst	*Crustaesporites*										
	Mabuitasaccites										
	Meristocorpus										
BPG	*Alisporites*			2	0.3	1	0.2	1	0.1	9	1.2
	Colpisaccites										
	Klausipollenites										
	Limitisporites			2	0.3	1	0.2	1	0.1	12	1.6
	Minutosaccus					1	0.2				
	Platysaccus			1	0.1	1	0.2			3	0.4
	Pteruchipollenites			2	0.3	1	0.2			3	0.4
	Scheuringipollenites										
	Vtreisporites										
BSPG	*Hamiapollenites*										
	Illinites										
	Lueckisporites										
	Protohaploxypinus			2	0.3						
	Striatoabieites										
	Striatopodocarpites										
PCPG	*Cycadopites*										
	Pakhapites										
	Vitattina			2	0.3						
	Weylandites										
Fungii	Fungii indet.	6	3.0	10	1.3	55	12.2	98	12.3	6	0.8
	Portalites			1	0.1						
Algae	*Botryococcus*									6	0.8
	Brazilea	1	0.5	5	0.7	13	2.9	21	2.6	9	1.2
Acritarchs	*Michrystridium?*					4	0.9	6	0.8		
Autoch.	**TOTAL**	200	100	750	100	450	100	800	100	750	100
Rework	**Spores**	4	2.0	26	3.5	117	20.5	192	19.4	105	12.2

Palynological Assemblages		3															
Facies association		X															
PBSJ		678		668		679		680		681		669		670		671	
	Genus	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%
	Potonieisporites			3	1.2	2	0.4			5	0.9	30	2.3				
	Tuberisaccites									2	0.4	15	1.2				
MPGst	*Crustaesporites*											5	0.4				
	Mabuitasaccites			2	0.8	6	1.1	2	0.5	9	1.6	134	10.3	11	5.0	15	4.7
	Meristocorpus							1	0.3	1	0.2	1	0.1			1	0.3
BPG	*Alisporites*	6	6.0	11	4.4	44	8.0	24	6.6	21	3.7	42	3.2	18	8.2	29	9.1
	Colpisaccites	3	3.0	2	0.8	3	0.5	5	1.4	8	1.4	5	0.4	1	0.5	2	0.6
	Klausipollenites			2	0.8	18	3.3	7	1.9	13	2.3	11	0.8	2	0.9	2	0.6
	Limitisporites			5	2.0	38	6.9	10	2.7	12	2.1	2	0.2				
	Minutosaccus							2	0.5								
	Platysaccus			6	2.4	6	1.1	5	1.4	10	1.8	4	0.3	1	0.5	5	1.6
	Pteruchipollenites	3	3.0	3	1.2	4	0.7	11	3.0	12	2.1	111	8.5	2	0.9		
	Scheuringipollenites	5	5.0	2	0.8	10	1.8	13	3.6	8	1.4	35	2.7	15	6.8	22	6.9
	Vtreisporites			3	1.2	3	0.5			2	0.4	4	0.3	1	0.5	2	0.6
BSPG	*Hamiapollenites*	5	5.0			9	1.6	5	1.4	3	0.5	113	8.7	15	6.8	23	7.2
	Illinites			1	0.4	1	0.2	2	0.5	7	1.2	20	1.5	3	1.4		
	Lueckisporites	3	3.0	2	0.8	4	0.7			4	0.7	13	1.0			3	0.9
	Protohaploxypinus	6	6.0	10	4.0	36	6.5	22	6.0	36	6.3	220	16.9	29	13.2	30	9.4
	Striatoabieites			2	0.8	3	0.5	2	0.5	8	1.4						
	Striatopodocarpites	2	2.0	1	0.4	5	0.9	5	1.4	18	3.2	7	0.5	4	1.8	1	0.3
PCPG	*Cycadopites*			3	1.2	7	1.3	5	1.4	6	1.1	3	0.2	3	1.4	2	0.6
	Pakhapites			3	1.2	11	2.0	5	1.4	10	1.8	13	1.0	1	0.5	8	2.5
	Vitattina	6	6.0	5	2.0	4	0.7	11	3.0	28	4.9	31	2.4	45	20.5	84	26.3
	Weylandites									7	1.2	10	0.8	11	5.0	24	7.5
Fungii	Fungii indet.							2	0.5	1	0.2			2	0.9		
	Portalites																
Algae	*Botryococcus*	7	7.0							1	0.2						
	Brazilea			9	3.6	9	1.6	7	1.9							6	1.9
Acritarchs	*Michrystridium?*																
Autoch.	**TOTAL**	100	100	250	100	550	100	365	100	570	100	1300	100	220	100	320	100
Rework	**Spores**																