

Palynoflora from the La Anita Formation (Maastrichtian), Austral-Magallanes Basin, Argentina

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Abstract: Here we describe the spore and pollen assemblages recovered from the La Anita Formation, Late Cretaceous, Austral-Magallanes Basin (~50°S). This unit shows a high diversity of spores, with subordinate gymnosperms (mainly represented by Podocarpaceae) and angiosperms (mainly represented by Proteaceae and Arecaceae). The abundance of these groups varies between the two fertile studied levels, being one dominated by ferns (mainly *Cyathidites minor* and *Laevigatosporites ovatus*) and the other by gymnosperms (*Podocarpidites* spp.). The presence of aquatic ferns (*Azollopsis*), diverse Podocarpaceae and key angiosperm taxa (such as *Arecipites*, *Clavatipollenites*, *Dichastopollenites*, and *Spinizonocolpites*) is indicative of warm and hyper-humid conditions. The great abundance of Arecaceae and the presence of some key taxa (e.g. *Azollopsis* sp., *Ericipites scabratus*, *Peninsulapollis gillii*, *Proteacidites* spp.) support a probable Maastrichtian age for the uppermost strata of the La Anita Formation. The multivariate statistical analysis here conducted showed that the La Anita Formation has its greatest similarity with the La Irene Formation (Maastrichtian from the Austral-Magallanes Basin). Both formations are also related with other coeval palynofloras from Patagonia and Antarctica.

Key words: Late Cretaceous, Austral-Magallanes Basin, Patagonia, palynology.

Resumen: Palinoflora de la Formación La Anita (Maastrichtiano), Cuenca Austral-Magallanes, Argentina. Se describen aquí la asociaciones palinológicas recuperadas de la Formación La Anita, Cretácico tardío, Cuenca Austral-Magallanes (~50°S). La unidad muestra una alta diversidad de esporas, con gimnospermas (principalmente representadas por Podocarpaceae) y angiospermas (principalmente representadas por Proteaceae y Arecaceae) subordinadas. La abundancia de estos grupos varía entre los dos niveles fértiles estudiados, siendo uno dominado por helechos (principalmente *Cyathidites minor* y *Laevigatosporites ovatus*) y otro por gimnospermas (*Podocarpidites* spp.). La presencia de helechos acuáticos (*Azollopsis*), diversas podocarpaceas y angiospermas megatérmicas (como *Arecipites*, *Clavatipollenites*, *Dichastopollenites*, y *Spinizonocolpites*) es indicativa de condiciones cálidas e hiper húmedas. La gran abundancia de Arecaceae y la presencia de algunos taxones diagnósticos temporalmente (e.g. *Azollopsis* sp., *Ericipites scabratus*, *Peninsulapollis gillii*, *Proteacidites* spp.) apoyan una probable edad Maastrichtiana para los niveles cuspidales de la Formación La Anita. El análisis estadístico multivariado mostró que la Formación La Anita posee sus mayores similitudes con la Formación La Irene (Maastrichtiano de la Cuenca Austral-Magallanes). Ambas formaciones se encuentran también relacionadas con otras palinofloras coetáneas de Patagonia y Antártida.

Palabras clave: Cretácico Superior, Cuenca Austral-Magallanes, Patagonia, palinología.

INTRODUCTION

The Late Cretaceous is a critical interval to understand the evolution of floras around the world, a time when angiosperms became dominant components in terrestrial ecosystems for the first time (Friis *et al.*, 2011; Lupia *et al.*, 1999; Nagalingun *et al.*, 2002; Barreda *et al.*, 2019), and a number of new lineages have their origin, such as Proteaceae and Nothofagaceae in the high southern latitudes (e.g. Dettmann & Thomson, 1987, Askin, 1990b; Cantrill & Poole, 2005). In southern South America terrestrial palynological records are sparse (Papú, 1988a, b, 1989; Baldoni, 1992; Baldoni & Askin, 1993; Papú, 2002; Povilauskas *et al.*, 2008; Povilauskas, 2010, 2011, 2012, 2013, 2016; Vallati, 2010; Novas *et al.*, 2019), with several geologic units with no information on their spore-pollen content. For this reason, the study of new assemblages is essential for evaluating the evolution of austral floras and will also serve as a basis to better evaluate the magnitude of the drop in plant diversity and abundance throughout the K/Pg boundary (Barreda *et al.*, 2012).

The purpose of this paper is to describe the palynological assemblages recovered from the La Anita Formation (Bianchi, 1967), Austral-Magallanes Basin, Southern Patagonia; to refine the age and the paleoclimatic conditions that prevailed during the deposition of this unit; and, to integrate and compare this results with what is known of Late Cretaceous palynofloras of Patagonia (La Irene, Lefipán, Loncoche, Monte Chico, Cerro Cazador, Allen and Paso del Sapo formations) and Antarctica (Lopez de Bertodano Formation) using statistical methods.

This is the first work in a series that aim to study and update the palynological fossil record from the Late Cretaceous in Patagonia in order to better understand the evolution of southern South American floras.

GEOLOGICAL SETTING AND STUDIED SECTION

The La Anita Formation is part of a prograd-ing siliciclastic wedge accumulated during the foreland stage of the Austral-Magallanes Basin (Santa Cruz Province, southern Argentina). It covers the deep-marine Alta Vista Formation, and is covered by continental deposits of the Cerro Fortaleza and La Irene formations (Macellari *et al.*, 1989; Moyano Paz *et al.*, 2018; Tettamanti *et al.*, 2018). The La Anita Formation is character-

ized by sandstones and pebbly sandstones, with subordinate mudstones and heterolithic deposits (Moyano Paz *et al.*, 2018). It was assigned to the Campanian based on both ammonites (Riccardi & Rolleri, 1980, Riccardi, 1983; Kraemer & Riccardi, 1997) and detrital zircons (Sickmann *et al.*, 2018; 2019).

The La Anita Formation was interpreted as a delta system with vertical variation on the relative roles of processes affecting it; thus, a wave-dominated lower unit and a fluvio-dominated upper unit were defined by Moyano Paz *et al.* (2018). Both units are separated by a regional erosion surface related to a relative sea level fall. The wave-dominated lower unit grades from the deep-marine fine-grained sediments of the Alta Vista Formation, into a dominantly sandy, gray-colored succession. The presence of trace fossils suites and the abundance of wave-generated structures, indicate high-energy conditions, associated with a high recurrence of storm events. However, the low abundance and diversity of these traces could be related to a stressing condition produced by low salinity and bottom oxygenation due to fluvial-discharge effects. The fluvio-dominated upper unit shows a general coarser grain size. It is composed by high-sinuosity, multi-story distributary channels, along with fine-grained deposits related to interdistributary areas, with no evidence of wave nor tidal influence. The upper unit shows evidence of deposition in a brackish-water environment, such as the presence of a trace suite attributable to a stressed expression of the *Skolithos* ichnofacies.

The studied section crops out 4 km south of Calafate City, Santa Cruz province; at the base of Calafate Hill, in a fresh cliff in the Calafate Creek (50°22'15.67"S 72°14'12.30"W; Fig. 1). This locality represents the uppermost facies of the upper unit of the La Anita Formation, and is characterized by fine- to medium-grained yellowish sandstone bodies with trough-cross stratification, tabular fine dark laminated organic-rich claystones, and channelized sandstone bodies with trough-cross stratification and abundant carbonaceous material (Fig. 2). Fossil leaf compressions of conifers and ferns were found; as well as leaves, fruits and seeds of angiosperms.

MATERIALS AND METHODS

Two levels from the La Anita Formation were productive for palynology: CCC-A from a coal level (collection number MPM-Pb-18963) and CCC-B from a siltstone level (collection number

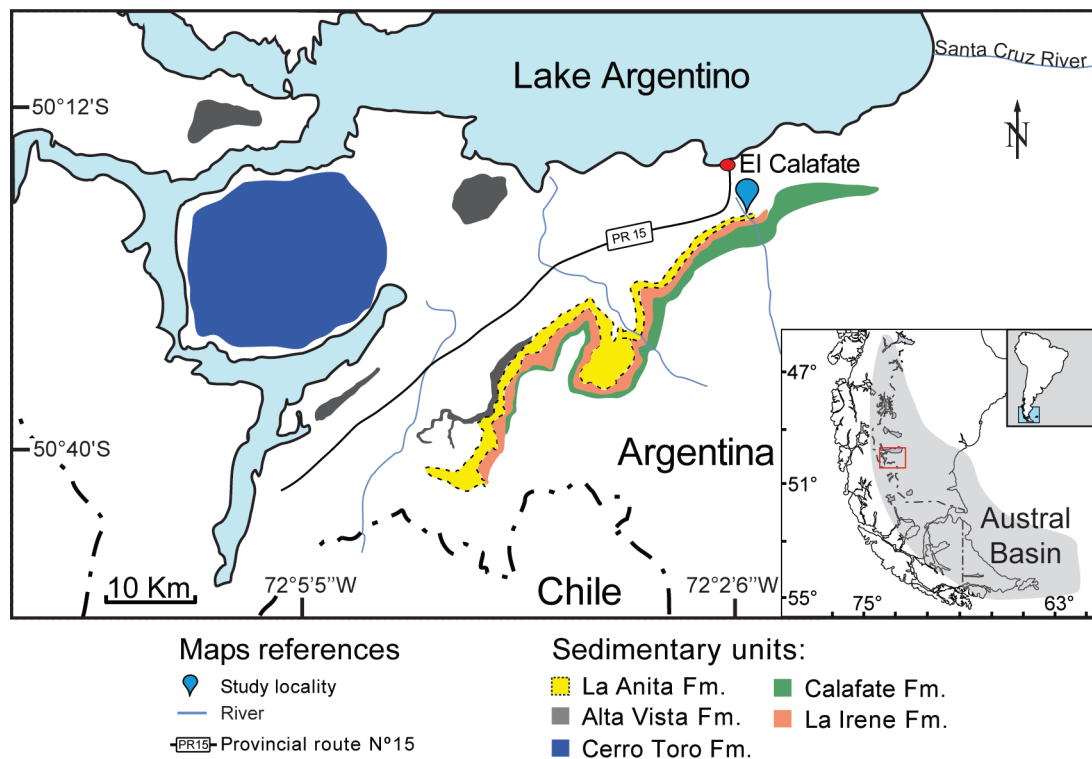


Fig. 1. Geological map of the studied area.

MPM-Pb-18964), both within interdistributary areas on a delta plain fine grained deposits (Fig. 2). Samples were processed following standard palynological techniques, and mounted in a glycerol mounting medium. The observations were made under a Leica DM2500 light microscope and the photographs were taken with a Leica DFC295 digital camera. Specimen locations refer to England Finder coordinates. In order to obtain the relative abundance of plant groups, counts of at least 300 individuals were conducted. Broken individuals were not counted, and tetrads and polyads were counted as one individual. The specimens are stored at the paleobotanical collection of the Museo Regional Provincial “Padre Jesús Molina”, Rio Gallegos, Santa Cruz Province (acronym MPM-Pb).

A presence/absence matrix was constructed (see Appendix) in order to compare the spore-pollen assemblages of the La Anita Formation with coeval palynofloras from the La Irene (Povilauskas *et al.*, 2008), Lefipán (Baldoni, 1992; Baldoni & Askin, 1993; Barreda *et al.*, 2012), Loncoche (Papú, 2002), Paso del Sapo (Papú, 1988a, b, 1989), Allen (Vallati, 2010), Monte Chico and Cerro Cazador (Povilauskas, 2010, 2011,

2012, 2013, 2016) formations from Argentina and the López de Bertodano Formation from the Antarctic Peninsula (Baldoni & Barreda, 1986; Dettmann & Thomson, 1987; Askin, 1990a, b, 1994; Dolding, 1992; Bowman *et al.*, 2014). A cluster analysis was conducted using the program PAST version 3.1 (Hammer *et al.*, 2001). The unweighted pair-group method (UPGMA) was chosen for constructing the dendrogram, and Jaccard Similarity Index was applied to measure similarities between palynofloras.

RESULTS

The recovered assemblages from the La Anita Formation at the Cerro Calafate locality are very well preserved and integrated by spores, pollen grains, plant tissue fragments and fungal remains. A total of 42 spores and pollen species were identified, representing 3 bryophytes, 14 ferns, 11 gymnosperms, 13 angiosperms and 1 fresh-water algae (Table 1).

The spore-pollen assemblage recovered from sample CCC-A is dominated by ferns (93.9%, mainly represented by *Cyathidites minor* and *Laevigatosporites ovatus*), followed by gymno-

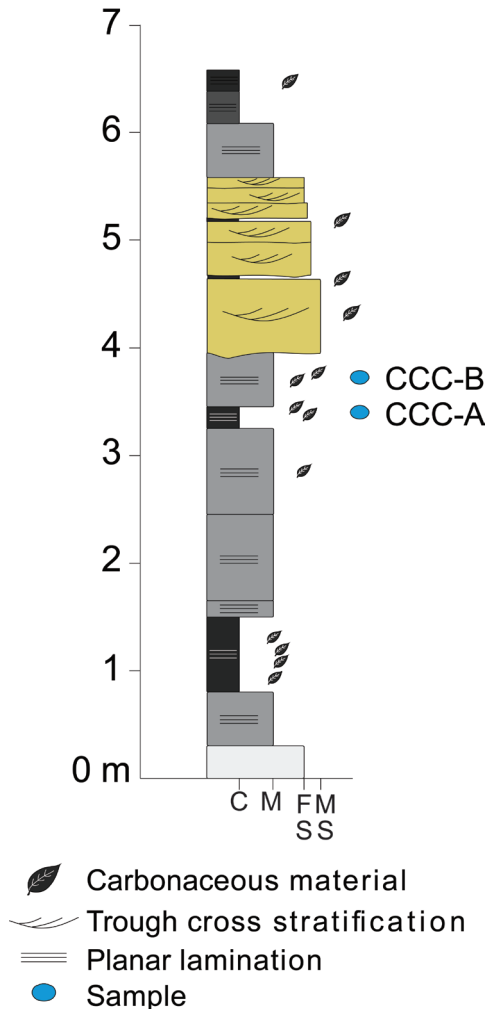


Fig. 2. Sedimentological section studied.

sperms (4.2%) and angiosperms (1.4%) (Table 2). Zygnetmataceae zygospores, *Classopollis* spp., *Ericipites scabratus*, *Liliacidites kaitangataensis*, *Peninsulapollis gillii*, *Spinizonocolpites hialinus* and *Tricolpites reticulatus* are exclusive from this level (Figs. 3, 4).

The assemblage recovered from sample CCC-B is dominated by gymnosperms (69.2%), followed by ferns (17.9%) and angiosperms (12.8%) (Table 2). The most important groups in this assemblage are: Podocarpaceae (67.6%), represented mainly by the genus *Podocarpidites*, and Arecaceae (11.5%), represented by *Arecipites minutiscabratus*. *Podocarpidites marwickii*, *P. rugulosus*, *Podocarpidites* sp., *?Rhoipites* sp., *Lewalanipollenites* sp., *Proteacidites* spp. and *Dichastopollenites* sp., are exclusive from this level (Figs. 3, 4).

Based on a presence/absence matrix of taxa, a cluster analysis was conducted, resulting in the dendrogram illustrated in Figure 5. Similarities between formations are generally low. A main group can be identified, composed by the La Anita, La Irene, Monte Chico, Cerro Cazador (Maastrichtian–Danian from Austral-Magallanes Basin), Loncoche (Maastrichtian from Neuquén Basin) and Lefipán (Maastrichtian–Danian from the Cañadón Asfalto Basin) formations. It can be divided in two subgroups: Subgroup A composed by the La Anita and La Irene formations, and Subgroup B composed by the Monte Chico, Cerro Cazador, Loncoche and Lefipán formations.

The lowest similarity values are held by the Lopez de Bertodano (Maastrichtian–Danian from Antarctic Peninsula) and Paso del Sapo (Campanian–Maastrichtian from the Cañadón Asfalto Basin) formations.

DISCUSSION AND CONCLUSIONS

The palynoflora recovered from the upper unit of the La Anita Formation suggests two different plant communities. Sample CCC-A has a high relative abundance of *Cyathidites minor* (both monads and polyads), with *Matonisporites equixinus*, *Spinizonocolpites hialinus* and Zygnetmataceae zygospores. The fern family Matoniaceae lives in the tropical regions of southeastern Asia (Tryon & Lugardon, 1990). *S. hialinus* is related to Arecaceae (Archangelsky, 1973; Martinez *et al.*, 2016) an angiosperm tropical family with low resistance to frosts (Heywood *et al.*, 2007). The Zygnetmataceae produce zygospores in clean, oxygen-rich, stagnant, shallow fresh water bodies, where the temperature can rise quickly to the level required for this process (van Geel, 1976). This association suggests a vegetation developed near a lake or a coastal marsh, under hiper-humid and warm conditions.

Sample CCC-B represents an inland forest, dominated by Podocarpaceae (*Podocarpidites* spp.) and Arecaceae (*Arecipites minutiscabratus*), with a minor presence of Proteaceae (*Lewalanipollis* sp., *Peninsulapollis* sp., and *Proteacidites* sp.).

Most of the spore and pollen species recovered from the La Anita Formation are long-ranging and can only give a general idea about the age of the upper levels of the La Anita Formation. The great abundance of Arecaceae at high and middle latitudes in the southern hemisphere is achieved towards the end of the Cretaceous (Barreda *et al.*, 2012). Also, *S. hialinus* was recorded in



Fig. 3. Spores and gymnosperms. A. *Appendicisporites* sp. (MPM-Pb-18964 d: E57/4). B. *Azolopsis* sp. (MPM-Pb-18963 b: G56). C. *Ceratosporites equalis* (MPM-Pb-18964 f: E54). D. *Cicatricosporites* cf. *minutaestriatus* (MPM-Pb-18964 b: F50). E. *Cicatricosporites hallei* (MPM-Pb-18964 f: G38). F. *Cyatheacidites annulatus* (MPM-Pb-18964 a: E41/3). G. *Foraminisporis asymmetricus* (MPM-Pb-18963 a: O41/2). H. *Interulobites* sp. (MPM-Pb-18964 a: T32/3). I. *Matonisporites equiexinus* (MPM-Pb-18963 b: P45). J. *Triporoletes reticulatus* (MPM-Pb-18963 b: H45/1). K. *Rugulatisporites* sp. tetrad (MPM-Pb-18963 a: J56); L. *Rugulatisporites* sp. (MPM-Pb-18963 a: Q55/2); M. Zygnemataceae zygospore (MPM-Pb-18963 d: C32/2). N. *Classopollis* sp. 1 (MPM-Pb-18963 c: T45). O. *Classopollis* sp. 2 (MPM-Pb-18963 e: O39). P. *Phyllocladidites mawsonii* (MPM-Pb-18963 a: D40/3). Q. *Podocarpidites* cf. *ellipticus* (MPM-Pb-18963 b: E50). R. *Podocarpites rugulosus* (MPM-Pb-18964 b: D40/3). S. *Microcachryidites antarcticus* (MPM-Pb-18963 c: L36/4). T. *Ephedripites notensis* (MPM-Pb-18964 g: S38/2). Scale bar: 10 μ m.

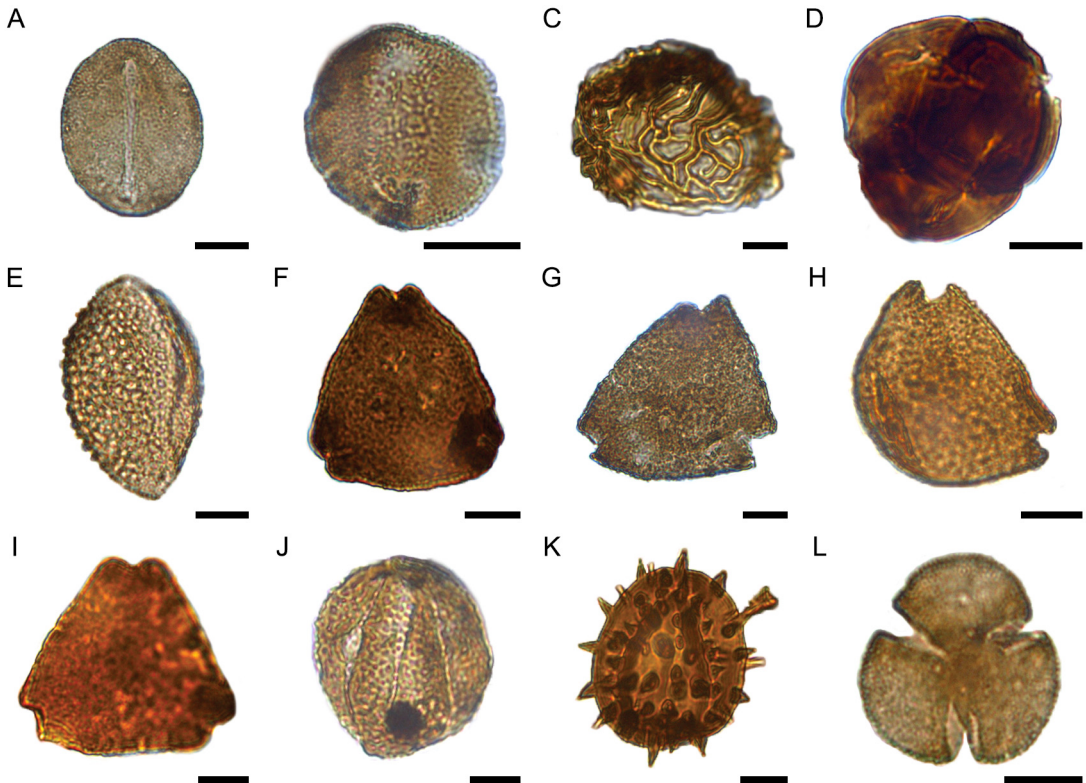


Fig. 4. Angiosperms. A. *Arecipites minutiscabratus* (MPM-Pb-18963 c (P2): U52). B. *Clavatipollenites hughesii* (MPM-Pb-18964 d, F50). C. *Dichastopollenites* sp. (MPM-Pb-18964 d: C53). D. *Ericipites scabratus* (MPM-Pb-18963 e: Q57). E. *Liliacidites kaitangataensis* (MPM-Pb-18963 c: V41/2). F. *Lewalanipollis* sp. (MPM-Pb-18964 f: G37). G. *Peninsulapollis* sp. (MPM-Pb-18964 e: S45). H. *Proteacidites* sp. 1 (MPM-Pb-18964 d: T59). I. *Proteacidites* sp. 2 (MPM-Pb-18964 d: C48). J. *?Rohipites* sp. (MPM-Pb-18964 d: L60/2). K. *Spinizonocolpites hialinus* (MPM-Pb-18963 c: N35/4). L. *Tricolpites reticulatus* (MPM-Pb-18964 g: C41/3). Scale bar: 10 μ m.

the Loncoche and Lefipán formations, from the Campanian–Maastrichtian of Patagonia (Baldoni & Askin, 1993; Papu, 2002; Barreda *et al.*, 2012). The oldest palynological record of Proteaceae in the Antarctic Peninsula occurs at the middle Santonian, extending to southern South America at the Campanian–Maastrichtian (Askin & Baldoni, 1998). In Argentina, *Peninsulapollis gillii* was first recorded from the Los Alamitos Formation of Campanian age (Papú & Sepúlveda, 1995), meanwhile *Proteacidites* was described in multiple Maastrichtian and Danian sequences (Baldoni & Askin, 1993; Povilauskas, 2010, 2013; Volkheimer *et al.*, 2007). The oldest records of *Ericipites scabratus* in Patagonia are from the Maastrichtian on both the Lefipán (Baldoni & Askin, 1993) and La Irene (Povilauskas *et al.*, 2008) formations. These records suggest a Late Cretaceous, probably Maastrichtian age for the upper sections of the La Anita Formation. Also, in the studied area, the La Anita Formation is

unconformably covered by the Maastrichtian La Irene Formation, restricting its maximum age (Povilauskas *et al.*, 2008).

Based on the cluster analysis, the La Anita Formation shows its greatest similarities with La Irene Formation. These units share 15 species: *C. equalis*, *C. minor*, *G. senonicus*, *L. ovatus*, *T. reticulatus*, *R. austroclavatidtes*, *M. antarcticus*, *P. elegans*, *P. ellipticus*, *A. minutiscabratus*, *E. scabratus*, *P. gillii*, *Proteacidites* sp., *Rhoipites* sp., and *S. hialinus*. The locality of the La Irene Formation studied by Povilauskas *et al.* (2008) is close both, geographically and stratigraphically, from the one presented here. Both formations share similarities on its inferred floral assemblage (a plant community dominated by ferns and angiosperms, with absence of Nothofagaceae) as well as its depositional conditions (a fluvio-dominated delta environment developed under warm and humid climatic conditions). The two abundance histograms pre-

Table 1. List of taxa.

Morphogenus	Affinity	Sample	
		CCC-A	CCC-B
<i>Appendicisporites</i> sp. Weyland & Krieger, 1953	Anemiaceae		X
<i>Azollopsis</i> sp.	Azollaceae	X	
<i>Biretisporites crassilabratus</i> Archangelsky, 1972	Hymenophyllaceae	X	X
<i>Ceratospores equalis</i> Cookson & Dettmann, 1958	Selaginellaceae/Lycopodiaceae	X	
<i>Cicatricosisporites cf. minutaestriatus</i> Pocock, 1964	Anemiaceae	X	X
<i>Cicatricosisporites hallei</i> Delcourt & Sprumont, 1955	Anemiaceae		X
<i>Cyathidites minor</i> Couper, 1953	Filicopsida	X	X
<i>Cyatheacidites annulatus</i> Cookson, 1947	Lophosoriaceae		X
<i>Densoisporites velatus</i> Weyland & Krieger, 1953	Selaginellaceae	X	
<i>Foraminisporis assymmetricus</i> Dettmann, 1963	Bryophyta	X	
<i>Gleicheniidites senonicus</i> Ross, 1949	Gleicheniaceae (<i>G. circinata</i>)		X
<i>Interulobites</i> sp.	¿Bryophyta		X
<i>Laevigatosporites ovatus</i> Wilson & Webster, 1946	Filicopsida	X	X
<i>Retitrites austroclavatidites</i> Cookson, 1953	Lycopodiaceae (<i>Lycopodium</i>)	X	
<i>Matonisporites equiexinus</i> Couper, 1958	Matoniaceae	X	
<i>Rugulatisporites</i> sp.	Osmundaceae	X	X
<i>Triporoletes reticulatus</i> (Pocock) Playford, 1971	Bryophyta (<i>Riccia</i>)	X	
Zygosporites indet.	Zygnemataceae	X	
<i>Araucariacites australis</i> Cookson, 1947	Araucariaceae	X	X
<i>Classopollis</i> sp. 1	Cheirolepidiaceae	X	
<i>Classopollis</i> sp. 2	Cheirolepidiaceae	X	
<i>Ephedripites notensis</i> Cookson, 1957	Ephedraceae	X	X
<i>Microcachryidites antarcticus</i> Cookson, 1947	Podocarpaceae	X	X
<i>Phyllocladidites mawsonii</i> Cookson, 1947	Podocarpaceae	X	
<i>Podocarpidites cf. ellipticus</i> Cookson, 1947	Podocarpaceae	X	X
<i>Podocarpidites marwickii</i> Couper, 1953	Podocarpaceae		X
<i>Podocarpidites rugulosus</i> Romero, 1977	Podocarpaceae		X
<i>Arecipites minutiscabratus</i> (McIntyre) Milne, 1988	Arecaceae	X	X
<i>Clavatipollenites hughesii</i> Couper, 1958	Chlorantaceae		X
<i>Dichastopollenites</i> sp.	?Nymphaeaceae (<i>Nymphaea</i>)		X
<i>Ericipites scabratus</i> Harris, 1965	Ericales	X	
<i>Lewalanipollis</i> sp.	Proteaceae		X
<i>Liliacidites kaitangataensis</i> Couper, 1953	Liliaceae/Iridaceae	X	
<i>Peninsulapollis gillii</i> Dettmann & Jarzen, 1988	Proteaceae (<i>Beauprea</i>)	X	
<i>Peninsulapollis</i> sp.	Proteaceae (<i>Beauprea</i>)		X
<i>Proteacidites</i> sp. 1	Proteaceae		X
<i>Proteacidites</i> sp. 2	Proteaceae		X
? <i>Rhoipites</i> sp.	Angiosperma incertae sedis.		X
<i>Spinizonocolpites hialinus</i> Archangelsky & Zamalao, 1986	Arecaceae	X	
<i>Tricolpites reticulatus</i> Cookson, 1947	Gunneraceae (<i>Gunnera</i>)	X	

sented by Povilauskas *et al.* (2008) are also similar with the counts presented here. One level is strongly dominated by trilete psilate spores, with low representation of gymnosperm and angiosperm pollen grains; and the second level shows

lesser abundance of spores and an increase in angiosperm pollen grains (mainly Arecaceae and Chloranthaceae). However, the La Anita Formation presents a much greater abundance of Podocarpaceae (67% in CCC-B) than the La Irene

Table 2. Counts expressed in absolute frequencies and percentages.

Taxonomic group	Sample			
	CCC-A		CCC-B	
	n°	%	n°	%
Anemiaceae	3	0.8	3	0.96
Filicopsida	322	91.7	45	14.42
Matoniaceae	5	1.4	–	–
Gleicheniaceae	–	–	3	0.96
Osmundaceae	–	–	2	0.64
Schyzaceae	–	–	3	0.96
Araucariaceae	10	2.8	5	1.6
Podocarpaceae	5	1.4	211	67.62
Arecaceae	5	1.4	36	11.53
Chlorantaceae	–	–	2	0.64
Proteaceae	–	–	2	0.64
Zygnemataceae	1	0.3	–	–
Total	351	100	312	100

Formation (4–10% in Povilauskas *et al.*, 2008).

The palynofloras from the Cerro Cazador and Monte Chico formations, show great similarities with those from the coeval Loncoche, Lefipán and La Irene formations (Povilauskas 2010, 2011, 2012, 2013, 2016). These Patagonian palynofloras share general characteristics, such as: great diversity and abundance of spores, presence of Arecaceae (*Arecipites*) and Liliaceae (*Liliacidites*), and low representation of Podocarpaceae. The palynoflora here studied also present these characteristics; but has a greater representation of Podocarpaceae.

The assemblages from the Lopez de Bertodano Formation (Antarctic Peninsula), represent a completely different floral setting: a podocarpaceous/*Nothofagidites* dominated rainforest, with great diversity of *Nothofagaceae*, *Proteaceae* and *Myrtaceae* (Dettmann & Thompson, 1987; Bowman *et al.*, 2014). These palynological assemblages show a mixed of cool temperate palynomorphs (such as *Nothofagidites* and *Phyllocladidites*) along with warmer climate indicators (particularly in the late Maastrichtian, such as *Peninsulapollis*, *Bombacidites* and *Anacolosidites*). The vegetation in the Antarctic Peninsula was probably zoned by altitude, with the megathermic plant associations occupying

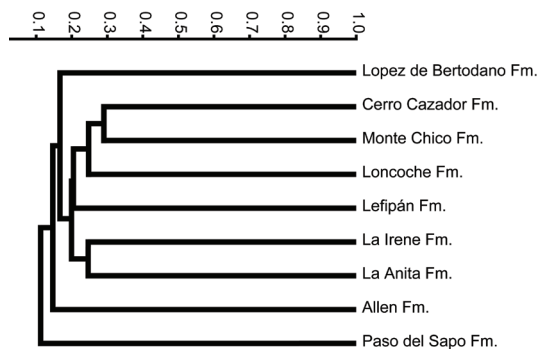


Fig. 5. Dendrogram derived from the cluster analysis.

coastal/lowland areas and cool climate associations in the higher altitude, inland areas (Askin, 1990b). These characteristics separate the palynofloras of the Antarctic Peninsula, from those of Patagonia, resulting in low similarity values among them.

The assemblage from the Allen Formation (Maastrichtian of the Neuquen Basin) have species characteristics from both, southern (*Cicatricosisporites*, *Lewalanipollis*, *Peninsulapollis*, *Podocarpidites*, and *Proteacidites*) and paleoequatorial latitudes (*Gabonisporis* and *Tricesticillus*). Interestingly, this scenario is somehow comparable to that previously reported for the Early Cretaceous of central Argentina, where a “Transition Zone” was defined (Pramparo, 1990). This unit only shows gross similarities with the La Anita Formation

Previous cluster analysis of Campanian–Maastrichtian palynofloras from Patagonia (Povilauskas *et al.*, 2008; Povilauskas, 2016), found great similarities between the Paso del Sapo Formation and other Patagonian palynofloras. However, our analysis shows only gross similarities among them; the observed differences are related to the fact that, in our analysis, we considered all the species recorded in the Paso del Sapo Formation (not only those share with the La Anita Formation) which highlights the high level of endemism of the Paso del Sapo Formation assemblages, with the exclusive presence of *Conbaculatisporites* sp., *Cycadopites follicularis*, *Cycadopites punctatus*, *Entylissa* sp., *Klulcisporites pachydictyus*, *Laevigatosporites gracilis*, *Laevigatosporites vulgaris*, *Marallisorites scabratus*, *Momipites fragilis*, *Podocarpidites verrucosus*, and *Waltzisporea* sp. among the most significant.

The new palynological records of the La Anita Formation widen our knowledge of the latest Late Cretaceous floras in southern Patagonia.

The similarities detected by our cluster analysis helps to refine the composition and geographic distribution of the Late Cretaceous austral vegetation previous to the floral turnover of the Cretaceous–Paleogene boundary.

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Appendix. Supplementary data to this article can be found online at revista.macn.gob.ar/ojs/index.php/RevMus/rt/suppFiles/664/0

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