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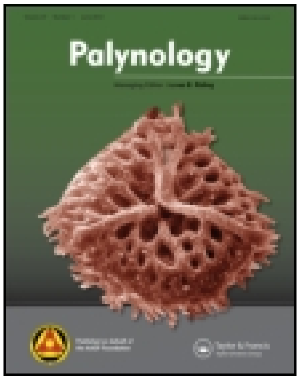

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Cretaceous cicatricose spores from north and central-western Argentina: taxonomic and biostratigraphical discussion

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Cretaceous cicatricose spores from north and central-western Argentina: taxonomic and biostratigraphical discussion

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Cicatricose spores have been described from Cretaceous basins worldwide. A complete revision of previous records from Argentina and other parts of South America is presented here, as well as the results of a detailed taxonomic study of the species found in the La Yesera and Lagarcito formations (north and central-western Argentina, respectively). Four genera and 11 species are described: *Cicatricosisporites cuneiformis*, *C. pramparoana*, *C.* sp. 1, *Fisciniasporites* sp. cf. *F. brevilaesuratus*, *F.* sp., *Nodosisporites* sp., *Ruffordiaspora australiensis*, *R. cardielensis*, *R. ludbrookiae*, *R.* cf. *R. ticoensis* and *R.* sp. 1. The genus *Fisciniasporites* is recorded for the first time in Argentina (in the La Yesera Formation), and similarly *Nodosisporites* in the San Luis Basin. The abundance of cicatricose spores is higher in the La Yesera Formation (8–54.2% of the total assemblage) than in the Lagarcito Formation (2–16%). An acme of cicatricose spore diversity in Argentina was recognised during the Aptian–Albian interval. Taxonomic studies of these types of spores are very important as they constitute a useful example of accurate descriptions and illustrations within a morphological group that has many misidentifications, and also considering the biostratigraphical significance of some species, e.g. *Cicatricosisporites cuneiformis* in Australia.

Keywords: cicatricose spores; Anemiaceae; Cretaceous; Salta Group Basin; San Luis Basin; Argentina

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1. Introduction

Cicatricose spores are produced by members of the leptosporangiate schizaealean ferns related to the modern genera *Anemia* Swartz and *Mohria* Swartz (Davies 1985), of the Family Anemiaceae (Smith et al. 2006). The genera *Cicatricosisporites*, *Plicatella*, and *Ruffordiaspora* appeared in the Late Jurassic, and rapidly diversified in the Tithonian (Dettmann & Clifford 1992), developing many costate patterns and shapes of the auriculae. During the Early Cretaceous, these genera continued radiating and achieved worldwide distribution. First occurrences of *Appendicisporites* are known from Cretaceous and younger sediments. This was genus was a common and diverse component of Early-Mid Cretaceous palynofloras (Dettmann & Clifford 1992). The forms with supramural ornamentation on the costa or muri such as *Nodosisporites* were established by the Aptian–Albian (Davies 1985), coincident with the acme of all cicatricose spores (Peyrot et al. 2007; Archangelsky & Archangelsky 2010a, 2010b). The contraction of this morphological group began by the Late Cretaceous, with decline in species diversity and abundances during the Turonian and throughout the Maastrichtian. Currently, the distribution is restricted to tropical and subtropical regions (Davies 1985; Dettmann & Clifford 1992).

A complete revision of the phylogeny and biogeography of cicatricose spores was made by Dettmann and Clifford (1992), who allocated the fossil genera as follows: *Appendicisporites*, *Cicatricosisporites*, *Nodosisporites*, and *Plicatella* in the modern *Anemia*-type, and *Ruffordiaspora* and *Fisciniasporites* in the fossil *Ruffordia*-type and *Schizaeopsis*-type respectively, both the last two genera have no post-Cretaceous records. They did not recognise at that time fossil spores of *Mohria*-type, a genus with a present distribution restricted to southern Africa and Madagascar, and characterised by the presence of hollow muri, which differs from the solid muri (sometimes with internal micropores) of the other cicatricose genera. Later, Archangelsky (2009) erected the genus *Palaeomohria* that comprises cicatricose spores with hollow muri from Albian sediments of Patagonia, Argentina (the Piedra Clavada Formation). He described two species and three informal types along with previous megafossils finds (Appert 1973), and concluded that the *Mohria* lineage may have had a southwestern (Gondwanan) distribution tracing back to the Early Cretaceous.

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Table 1. South American records of Cretaceous cicatricose spore species. Brazil: 1. Sousa Formation, Rio do Peixe Basin (Valanginian–Barremian?; Lima & Coelho 1987); 2. Barreiras Group (Aptian; Lima et al. 1980); 3. Rio da Batateira Formation, Araripe Basin (Aptian; Coimbra et al. 2002); 4. Santana and Arajara formations, Araripe Basin (Aptian–Albian; Lima 1978; Coimbra et al. 2002); 5. Muribeca and Riachuelo Formation, Sergipe Basin (Aptian–Albian; Carvalho 2004); 6. Exu Formation, Araripe Basin (Albian; Lima 1978); 7. Preguicas and Agua Doce formations, Barreirinhas Basin (Albian–Cenomanian; Herngreen 1973); 8. Potiguar Basin (Albian–Maastrichtian; Santos et al. 1994); 9. Gramame Formation (Maastrichtian; Ashraf & Stinnesbeck 1988); Chile: 10. Springhill Formation, Magallanes Basin (Hauterivian; Cranwell & Srivastava 2009); Colombia: 11. Quetame Massif (Aptian–Cenomanian; Pons 1988); 12. Une Formation (Albian–Cenomanian; Herngreen & Dueñas Jimenez 1990); Perú: 13. Arequipa Basin (Valanginian–Hauterivian?; Prámparo & Batty 1994); 14. Oriente Basin (Albian; Brenner 1968); Uruguay: 15. Castellanos Formation, Santa Lucía Basin (Albian; Campos et al. 1998); Venezuela: 16. Temblador Formation (?Aptian–Early Albian; Sinanoglu 1984).

Taxa \ Country - Formation	Brazil									Chile	Colombia		Peru		Uruguay	Venezuela
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Appendicisporites jansonii Pocock 1962										•						
A. parviangulatus Döring 1966	•															
A. sellingii Pocock 1964	•															
A. sp. A Cranwell & Srivastava 2009										•						
A. sp. in Campos, García, Dino, Veroslavsky, Saad, & Fulfaro 1998															•	
Cicatricosisporites annulatus Archangelsky & Gamerro 1966											•					
C. augustus Singh 1971										•						
C. avnimelechi Horowitz 1970		•	•	•		•		•							•	•
C. berouensis Jardiné & Magloire1965											•					
C. crassistriatus Burger 1966	•															
C. dorogensis Potonié & Gelletich 1933				•					•							
C. exilioides (Malyavkina) Dorhöfer 1977	•															
C. hallei/venustus - formgroup (in Herngreen, 1973)							•									
C. hughesii Dettmann 1963										•						
C. microstriatus Jardiné & Magloire 1965	•		•	•				•							•	
C. minutaestriatus (Bolkhovitina) Pocock 1964	•															
C. nuni Horowitz 1970		•		•		•		•								
C. perforatus (Markova) Döring 1965							•									
C. potomacensis Brenner 1963 (?*Fisciniaesporites*)																•
C. pseudotripartitus (Bolkhovitina) Dettmann 1963									•							
C. purbeckensis Norris 1969				•												
C. recticicatricosus Döring 1965	•															•
C. sewardi Delcourt & Sprumont 1955	•															
C. stoveri Pocock 1964	•															
C. subrotundus Brenner 1963	•															•
C. venustus Deák 1963												•				
C. sp. cf. *C. augustus* Singh 1971	•															
C. sp. cf. *C. aralica* (Bolkhovitina) Brenner 1963				•												
C. sp. cf. *C. hallei* Delcourt & Sprumont 1955											•					
C. sp. cf. *C. proxiradatus* Kemp 1970													•			
C . sp. cf. *C. subrotundus* Brenner 1963				•		•					•					
C . sp. cf. *C. venustus* Deák 1963				•		•										
C . spp				•	•		•				•	•				•
Fisciniaesporites brevilaesuratus (Couper) Dettmann & Clifford 1992		•		•												
Ruffordiaspora australiensis (Cookson) Dettmann & Clifford 1992							•		•		•			•		•
R. ludbrookiae (Dettmann) Detmann & Clifford 1992										•						

Wilkström et al. (2002) presented a phylogenetic analysis of living members of the Schizaeales based on molecular data. They observed a basal split separating *Lygodium* from the other genera and a close relationship between *Mohria* and *Anemia*. They also mentioned the uncertainties that exist when relating the fossil record to living species whereby fossils showing intermediate morphologies, such as macrofossils of *Schizaeopsis* Berry, have *Schizaea*-like fronds but *Anemia*/*Mohria*-like spores.

Some previous works documenting records of cicatricose spores from non-Argentinian South American basins are included in Table 1. In Argentina, the oldest cicatricose spore record is from the Vaca Muerta Formation (Tithonian, Neuquén Basin in the Caichigüe area; Figure 1, Table 2), and was originally designated as *Appendicisporites* sp. A by Volkheimer and Quattrocchio (1975), but subsequently transferred to *Ruffordiaspora ludbrookiae* by Archangelsky and Archangelsky (2010a). During the Early Cretaceous, spores of the family Anemiaceae were frequent components of palynomorph assemblages from the Austral (Baldoni & Archangelsky 1983; Archangelsky & Archangelsky 2010a, 2010b) and Neuquén basins (Volkheimer & Prámparo 1984; Prámparo & Volkheimer 1999). In the Aptian–Albian interval, there was an increase in the abundance and diversity of this morphological group (Prámparo 1989; Vallati 2006; Narváez & Prámparo 2009; Archangelsky & Archangelsky 2010a, 2010b) (Tables 2 and 3), in accordance with the global trend.

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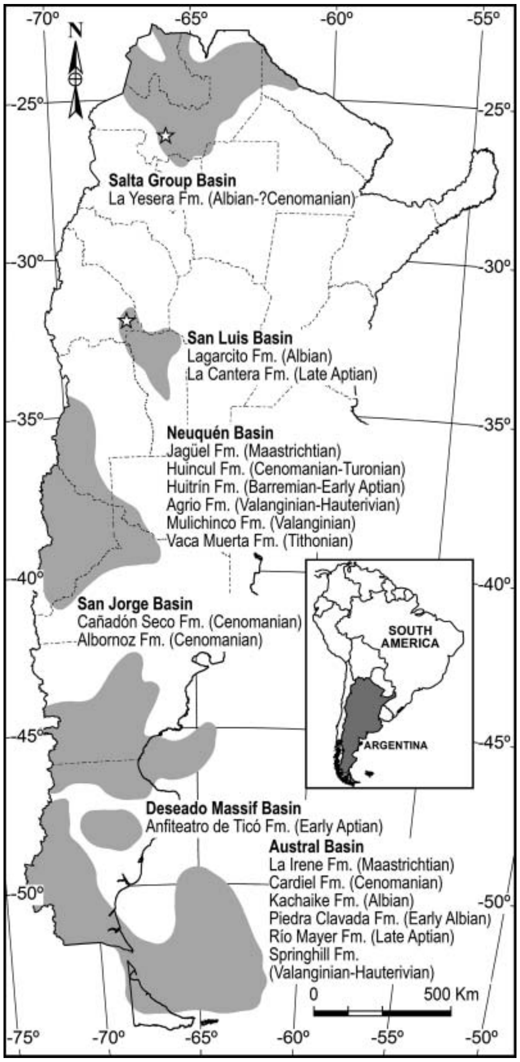

Figure 1. Location map of Argentinian basins and the geological units with cicatricose spore records mentioned in the text. Stars show the localities studied in this paper: Pucará Valley, Salta Province (Salta Group Basin) and Sierra de Guayaguas, San Juan Province (San Luis Basin).

Cicatricose spore occurrences from Late Cretaceous Argentinian strata are relatively scarce but include: the Albian–Cenomanian Cañadón Seco Formation, San Jorge Basin (Archangelsky et al. 1994); the Albian?–Cenomanian Huincul Formation, Neuquén Basin (Vallati 2001); the Cenomanian Albornoz Formation, San Jorge Basin (Vallati 1993); the Cenomanian Cardiel Formation, Austral Basin (Archangelsky & Archangelsky 2010a, 2010b), the Maastrichtian Jagüel Formation, Neuquén Basin (Prámparo & Papú 2002); and the Maastrichtian La Irene Formation, Austral Basin (Povilauskas et al. 2008) (Table 2).

Relevant previous studies dealing exclusively with the systematics of Cretaceous cicatricose spores from Argentina were carried out by Prámparo (1989) in the San Luis Basin (La Cantera Formation, Late Aptian–Albian), Archangelsky (2009) in the Austral Basin (Piedra Clavada Formation, Albian), and Archangelsky and Archangelsky (2010a, 2010b) also in the Austral Basin (Río Mayer, Piedra Clavada, Kachaike, and Cardiel formations, Valanginian–Albian). It is important to highlight the comparative table that Archangelsky & Archangelsky (2010b) created based on a series of morphological characters that they observed and measured in the cicatricose spores at different orientations (see Archangelsky & Archangelsky 2010b, p. 181). They mention that current microscopy techniques can improve the definition of morphological characters and allow the appreciation of their permanence or variability in both time and space. Hence, the aim of this paper is to present further palynological data (taxonomic discussions and species distributions) from two Lower Cretaceous formations in Argentina (the La Yesera and Lagarcito formations) in order to complete the picture of this morphological group in terms of species diversity and distribution in Argentina and South America, and to contribute to the elucidation of the biostratigraphical relevance of these taxa.

2. Materials and methods

The palynofloras which are the subject of this contribution come from two Cretaceous (Late Aptian to Cenomanian) geological units exposed in two different basins located between 22° to 35° south. They consist of three samples from the La Yesera Formation and six samples from the Lagarcito Formation. The palynological samples from the La Yesera Formation (Salta Group Basin, Figure 1) were collected from outcrops in the Pucará Valley, southwestern Salta province. At this locality, the basal unit of the La Yesera Formation, the Yacutuy Member (1000 m thick) consists of sandstones and conglomerates. The middle unit, the Las Chacras Member (660 m thick) consists of pelites and scarce sandstones, as well as a pelitic interval (the Brealito Member, 290 m thick). The upper unit is the Don Bartolo Member (330 m) composed of sandstones, pelites and conglomerates (Sabino 2004). According to Sabino (2002), the Brealito Member deposits correspond to a permanent lake, elongated along a north-south axis. Considering the stratigraphical ranges of the palynomorphs (Narváez & Prámparo 2009) and the radiometric age of the Isonza Basalt, coeval with the Don Bartolo Member (Valencio et al. 1976), an Albian–Cenomanian age is suggested for the La Yesera Formation. Two samples yielding cicatricose spores belong to the top of the Brealito Member (catalogue numbers 8435 and 8436), and the other to the Don Bartolo Member (number 8449).

The Lagarcito Formation comprises siliciclastic fluvio-lacustrine sediments deposited in an extensional

Table 2. Cicatricose spore records in Argentina. Salta Group Basin: 1. La Yesera Formation (Albian–?Cenomanian; this work); San Luis Basin: 2. La Cantera Formation (Late Aptian; Prámparo 1989); 3. Lagarcito Formation (Albian; this work); Neuquén Basin: 4. Vaca Muerta Formation (Tithonian; Volkheimer & Quattrocchio 1975); 5. Mulichinco and Agrio formations (Valanginian–Hauterivian; Volkheimer & Prámparo 1984; Prámparo & Volkheimer 1999; Quattrocchio et al. 1999); 6. Huitrín Formation (Barremian–Early Aptian; Volkheimer & Quattrocchio 1975; Volkheimer & Salas 1976); 7. Huincul Formation (Cenomanian–Turonian; Vallati 2001); 8. Jagüel Formation (Maastrichtian; Prámparo & Papú 2002); San Jorge Basin: 9. Albornoz Formation (Cenomanian; Vallati 1993); 10. Cañadón Seco Formation (Cenomanian; Archangelsky et al. 1994); Deseado Massif Basin: 11. Anfiteatro de Ticó Formation (Early Aptian; Archangelsky & Gamerro 1966; Archangelsky & Archangelsky 2010a,b); Austral Basin: 12. Springhill Formation (Valanginian–Hauterivian; Baldoni & Archangelsky 1983; Ottone & Aguirre Urreta 2000; Quattrocchio et al. 2006); 13. Río Mayer Formation (Late Aptian; Medina et al. 2008; Perez Loinaze et al. 2012; Archangelsky et al. 2012); 14. Piedra Clavada Formation (Early Albian; Archangelsky et al. 2008; Medina et al. 2008; Archangelsky 2009; Archangelsky & Archangelsky 2010a,b); 15. Kachaike Formation (Albian; Baldoni et al. 2001; Archangelsky & Llorens 2005; Archangelsky & Archangelsky 2010a,b; Perez Loinaze et al. 2012; Archangelsky et al. 2012); 16. Cardiel Formation (Cenomanian; Archangelsky & Archangelsky 2010a,b); 17. La Irene Formation (Maastrichtian; Povilauskas et al. 2008).

Taxa \ Basin / Formation	Salta Group	San Luis		Neuquén					San Jorge		Deseado Massif	Austral					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Appendicisporites potomacensis Brenner 1963													•	•	•	•	
A. cf. *A. giganticus* Groot & Groot 1962															•		
A. cf. *A. potomacensis* Brenner 1963													•		•		
A. sp. cf. *A. pschekhaensis* (Bolkhovitina) Pocock 1964													•				
A. cf. *A. unicus* (Markova in Samoilovich & Mtchedlishvili) Singh 1964														•	•		
A. spp.		•				•			•			•	•	•	•		
Cicatricosisporites abacus Burger 1966												•					
C. annulatus Archangelsky & Gamerro 1966 (*Fisciniaesporites* ?)											•		•	•	•		
C. cuneiformis Pocock 1964	•												•	•	•	•	
C. hughesii Dettmann 1963										•	•		•	•	•		
C. minutaestriatus (Bolkhovitina) Pocock 1964															•		
C. pramparoana Archangelsky & Archangelsky 2010b		•	•										•	•	•		
C. venustus Deák 1963														•	•	•	
C. cf. *C. hallei* Delcourt & Sprumont 1955													•		•	•	
C. cf. *C. minutaestriatus* (Bolkhovitina) Pocock 1964													•	•	•		
C. cf. *C. venustus* Deák 1963														•			
C. spp.	•	•			•		•	•	•	•			•	•	•		
Fisciniaesporites sp. cf. *F. brevilaesuratus* (Couper) Dettmann & Clifford 1992	•																
F. sp.	•																
Nodosisporites crenimurus (Srivastava) Davies 1986													•		•		
N. macrobaculatus Archangelsky & Llorens 2005														•	•	•	
N. sp. cf. *N. genuinus* (Bolkhovitina) Davies 1985														•			
N. spp.			•							•			•				
Palaeomohria patagonica Archangelsky 2009														•	•		
Plicatella archangelskyi (Archangelsky & Gamerro) Davies 1985											•						
P. baqueroensis (Archangelsky & Gamerro) Davies 1985		•									•			•	•		
P. jansonii (Pocock) Davies 1985														•			
P. pseudotripartita (Bolkhovitina) Archangelsky & Archangelsky 2010a													•		•		
P. sp. cf. *P. baqueroensis* (Archangelsky & Gamerro) Davies 1985											•				•		
P. sp. cf. *P. degenerata* (Thiergart) Davies 1985														•			
P. spp.		•									•	•			•		
Ruffordiaspora australiensis (Cookson) Dettmann & Clifford 1992		•	•			•				•	•	•	•	•	•	•	•
R. cardielensis Archangelsky & Archangelsky 2010b			•										•	•	•		
R. ludbrookiae (Dettmann) Detmann & Clifford 1992	•		•	•							•		•	•	•		
R. ticoensis (Archangelsky & Gamerro) A. Archangelsky, S. Archangelsky, Poiré & Canessa 2008											•	•	•	•	•		
R. cf. *R. crassiterminatus* (Hedlund) Archangelsky & Archangelsky 2010b														•	•		
R. cf. *R. ticoensis* (Archangelsky & Gamerro) A. Archangelsky, S. Archangelsky, Poiré & Canessa 2008	•										•	•		•	•		
R. spp.	•													•			

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Table 3. Distribution of selected cicatricose species in Argentinian basins. Those taxa in open nomenclature were not considered for this chart. The interval with highest diversity is highlighted in grey.

Taxa / Period-Age	Jurassic	Cretaceous											
	Late	Early						Late					
	Tith	Berr	Val	Hau	Barr	Apt	Alb	Cen	Tur	Con	San	Cam	Maas
Ruffordiaspora ludbrookiae	—	····	····	····	····	—	—	····					
Ruffordiaspora ticoensis			—	—	····	—	—						
Cicatricocisporites abacus			—	—									
Ruffordiaspora australiensis			—	—	—	—	—	—	····	····	····	····	—
Plicatella archangelskyi						—							
Cicatricosisporites annulatus						—	—						
Plicatella baqueroensis						—	—						
Cicatricosisporites pramparoana						—	—						
Nodosisporites crenimurus						—	—						
Plicatella pseudotripartita						—	—						
Ruffordiaspora cardielensis						—	—						
Appendicisporites potomacensis						—	—	—					
Cicatricosisporites cuneiformis						—	—	—					
Cicatricosisporites hughesii						—	—	—					
Palaeomohria patagonica							—						
Plicatella jansonii							—						
Cicatricosisporites venustus							—	—					
Nodosisporites macrobaculatus							—	—					

Cretaceous basin corresponding to the Gigante Group, San Luis Basin (Rivarola & Spalletti 2006; Figure 1). Chiappe et al. (1998) assigned an Albian age for the formation based on the fossil content (conchostracans, pleuropholid fishes, and pterosaurs). Palynomorph samples come from well-exposed pelites from the east of the Sierra de Guayaguas, San Juan province, and correspond to the 'La Yesera Sur' section (detailed location map and stratigraphical column in Prámparo et al. 2005). The psamopelitic-evaporitic sequence has gypsum and anhydrite intercalations and yields abundant conchostracans and ostracods, together with a rich palynoflora of continental (fluvio-lacustrine) origin (Prámparo & Milana 1999; Prámparo et al. 2005; Mego & Prámparo 2011). The catalogue numbers of the palynological samples studied are 5861–5862, 5967–5969, and 6595. Detailed studies of the complete polynomorph associations from both formations are in preparation.

The physical and chemical extraction of palynomorphs was performed in the Paleopalynological Laboratory at IANIGLA (Instituto Argentino de Nivología, Glaciología y Ciencias Ambientales, Mendoza, Argentina). Samples were treated with hydrochloric and hydrofluoric acids following standard palynological processing techniques (Volkheimer & Melendi 1976). Residues were sieved with a 10-μm nylon mesh sieve and slides were examined with a light microscope (Olympus BX50 with an adapted digital camera) for the qualitative and quantitative assessment of palynomorphs. Specimens were located on the slide using an England Finder graticule. The material was also analysed with a scanning electron microscopy at LABMEM (Laboratorio de Microscopía Electrónica y Microanálisis, Universidad Nacional de San Luis) and MACN (Museo Argentino de Ciencias Naturales 'Bernardino Rivadavia', Buenos Aires). The slides are stored at the Paleopalynological Collection at IANIGLA (MPLP: Mendoza-Paleopalinoteca-Laboratorio-Paleopalinología).

3. Systematic palaeontology

All spores with cicatricose or canaliculate sculpture found in the La Yesera and Lagarcito formations are listed in Appendix 1. Eleven species of cicatricose spores are described below. To describe the spores, we have followed the terminology of Punt et al. (2007). We also took into account the list of morphological characters observed and measured by Archangelsky & Archangelsky (2010b) to unify criteria for genera and species assignments. This analysis resulted in a new comparative table (Table 4), from which we characterized Cretaceous species from north and central-western Argentinian palynofloras. The distribution of the species described here, as well as cicatricose taxa from other Argentinian Cretaceous strata, are included in Table 2. Comparisons are mainly focused on cicatricose spore records from other Argentinian basins.

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Table 4. Comparative chart showing the spore morphological features of the cicatricose species found in the La Yesera, La Cantera (Prámparo 1989) and Lagarcito formations, following the criteria of Archangelsky and Archangelsky (2010b).

Features		Taxa: *C. cuneiformis*	*C. pramparoana*	*C.* sp. 1	*F.* sp. cf. *F. brevilaesuratus*	*F.* sp.	*Nodosisporites* sp.	*R. australiensis*	*R. cardielensis*	*R. ludbrookiae*	*R.* cf. *R. ticoensis*	*R.* sp. 1
Amb	circular											
	subtriangular/subcircular	•		•		•			•			
	triangular – straight				•			•				•
	triangular – concave											
	triangular – convex	•	•		•	•	•	•	•	•	•	•
Diameter (μm)	equatorial	53–85	86	90	46–81	97–109	55	43–45	41–62	59–110	78–85	74–100
	polar					82			32			92
Laesura	simple	•	•	•	•	•		•	•	•	•	•
	with lips (μm)	2.5–6			1–6		3–4		1–3	4		
	with margo (μm)											7–12
	straight	•	•	•	•	•	•	•	•	•	•	•
	sinuous				•							
	1/2				•	•						
	2/3 - 3/4	•	•	•	•	•	•					
	1							•	•	•	•	•
Sculpture	cicatricose						•					
	canaliculate	•	•	•	•							
	combined					•		•	•	•	•	•
Muri	width (μm)	2–5	1.5	5–6	2–5	6–10	2	1.5–2	1–3	1.5–7	5–8	4–10
	thickness (μm)	0.8–1.5	1	1.5–2	0.8–1.5	2–5	1.5	1.5	1–1.8	1.5–3	2	2–3
	rounded muri	•	•		•	•	•	•	•	•	•	•
	flat muri			•								
	acute muri											
	straight	•	•	•	•	•	•	•	•	•	•	•
	sinuous		•				•		•		•	•
	with sculptural elements						•					
	4 muri + 4 furrows (μm)	12–22	12	28–30	12-20	33–42	20	14	12–22	15–42	30–40	32–53
	simple						•		•		•	•
	bifurcate	•	•	•	•	•		•	•	•		
	with porosity	•			•							
	solid	•	•	•	•	•	•	•	•	•	•	•
	with channel											
	no. in equatorial profile	1–9	8		2–5	2	2	1–2	2–3	2–3	1	1–2
	continuous lateral	•	•	•	•	•						
	discontinuous lateral						•	•	•	•	•	•
Furrows	width (μm)	0.5–1	0.5	1–2	0.5–1	2–6	2–3	1–2	1–4	1–6	1–5	3–7
Muri in proximal face	max no. per series	5–9	12	8	4–8	4–5	3–4	4–5	2–4	4–5	3	2–4
	perpendicular to equator	•		•								
	parallel to equator	•	•	•	•	•	•	•	•	•	•	•
	oblique to equator	•	•	•								
	spiral series in equator				•	•						
Muri in distal face	wedge pattern	•	•	•	•	•						•
	parallel to equator						?	•	•	•	•	•
Exine	width (μm)	0.5	0.5	0.5	0.5–0.7	0.5	0.5	0.5	0.5	0.5–0.8	0.5–0.8	0.5–0.8

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Genus *Cicatricosisporites* Potonié & Gelletich 1933
Type species. *Cicatricosisporites dorogensis* Potonié & Gelletich 1933

Cicatricosisporites cuneiformis Pocock 1964
Plate 1, figures 1–3

Description. Trilete spores, amb subcircular to triangular with convex sides and rounded angles. Laesurae with lips (2.5–6 μm wide), straight, 2/3 to 3/4 of the total length of the radius, distal face convex. Exine 0.5 μm thick, with canaliculate sculpture, muri of 2–5 μm width and 0.8–1.5 μm thick, straight, sometimes branching, solid or with a distinct internal microporosity in the exine. Proximal face with three series of 5–9 muri each, at least one of them oblique to the equator, the others can be parallel, oblique or perpendicular to the equator; the muri of the parallel series coalesce in the disto-equatorial radial regions with the muri of the neighbouring series; the muri of the oblique or perpendicular series continuing onto the distal face and coalescing in the opposite angle, forming a wedge pattern. Furrows 0.5–1 μm wide. A set of four muri and furrows at distal face measures 12–22 μm across.
Dimensions. Equatorial diameter: 53–(69)–85 μm (12 specimens).
Studied material. La Yesera Formation: 8435K: P40/2; 8436R: O42; 8449B: W34; 8449H: Q46/1; 8449I: V29; 8449K: Y33; 8449V: Q36 MPLP. 8449(4) SEM LABMEN; 8449(1) SEM MACN.
Comparison. *Cicatricosisporites* sp. in Archangelsky & Llorens (2005) resembles our specimens but the former has wider furrows (1.5–2.5 μm) and also wider sets of four adjacent muri and furrows (20–30 μm).
Remarks. The first appearance of *C. cuneiformis* is used to mark the base of a subzone equivalent to the upper part of the Upper *Coptospora paradoxa* Zone of Dettmann & Playford (1969) in southeast Australia (Wagstaff et al. 2012).

Cicatricosisporites pramparoana Archangelsky & Archangelsky 2010b
Plate 1, figure 4

Description. Trilete spores, amb triangular with convex sides and rounded angles. Laesurae simple, straight, 2/3 of the total length of the radius, distal face convex. Exine 0.5 μm thick, with canaliculate sculpture, muri of 1.5 μm width and 1 μm thick, straight to sinuous, sometimes branching, solid. Proximal face with three series of up to 12 muri each, two series running parallel to the equator and coalescing in the disto-equatorial radial regions with the muri of the neighbouring series, the other series of muri running obliquely to equator and continuing through distal face, coalescing in the opposite angle, forming a wedge pattern. Furrows 0.5 μm wide. A set of four muri and furrows at distal face measures ca. 12 μm across.
Dimensions. Equatorial diameter: 86 μm (1 specimen).
Studied material. Lagarcito Formation: 5968F: L36/2 MPLP.
Comparison. *Cicatricosisporites* sp. illustrated in Vallati (2001) (50 μm, Huincul Formation, Neuquén Basin) resembles *C. pramparoana*, but it is a single specimen and not well preserved.
Remarks. According to Archangelsky & Archangelsky (2010b), *Appendicisporites* cf. *A. macalisteri* described by Prámparo (1989) from the La Cantera Formation (San Luis Basin) corresponds to *C. pramparoana*.

Cicatricosisporites sp. 1
Plate 1, figure 5

Description. Trilete spore, amb subcircular. Laesura hardly distinct, simple, straight, 2/3 of the total length of the radius, distal face convex. Exine 0.5 μm thick, with canaliculate sculpture, flat-topped muri 5–6 μm wide and 1.5–2 μm thick, straight, sometimes branching, solid. Proximal face with three series of up to 8 muri each, parallel, oblique or perpendicular to the equator; one or two of these series continuing onto the distal face, and coalescing in the opposite angle, forming a wedge pattern. Furrows 1–2 μm wide. A set of four muri and furrows at the distal face measures 28–30 μm across.
Dimensions. Equatorial diameter: 90 μm (1 specimen).
Studied material. La Yesera Formation: 8435B: T21/1 MPLP.
Comparison. The type species of the genus *Cicatricosisporites* (*C. dorogensis* Potonié & Gelletich 1933) is similar to our specimen of *C.* sp. 1, but it is smaller (59–68 μm), and has thinner muri (ca. 4 μm).

Genus *Fisciniasporites* Dettmann & Clifford 1992

Type species. *Fisciniasporites potomacensis* (Brenner) Dettmann & Clifford 1992
Remarks. Dettmann & Clifford (1992) erected the genus *Fisciniasporites* to include those spores with five series of muri formerly included in *Cicatricosisporites*.

Fisciniasporites sp. cf. *F. brevilaesuratus* (Couper) Dettmann & Clifford 1992
Plate 1, figures 6–10

Description. Trilete spores, amb triangular with straight to convex sides and rounded angles. Laesurae simple or with lips (1–6 μm wide), straight, 1/2 to 3/4 of the total length of the radius, distal face convex. Exine 0.5–0.7 μm thick, with canaliculate sculpture, muri 2–5 μm width and 0.8–1.5 μm thick, straight, sometimes branching, solid or with a distinct internal microporosity in the exine. Proximal face with three series of 4–8 muri each,

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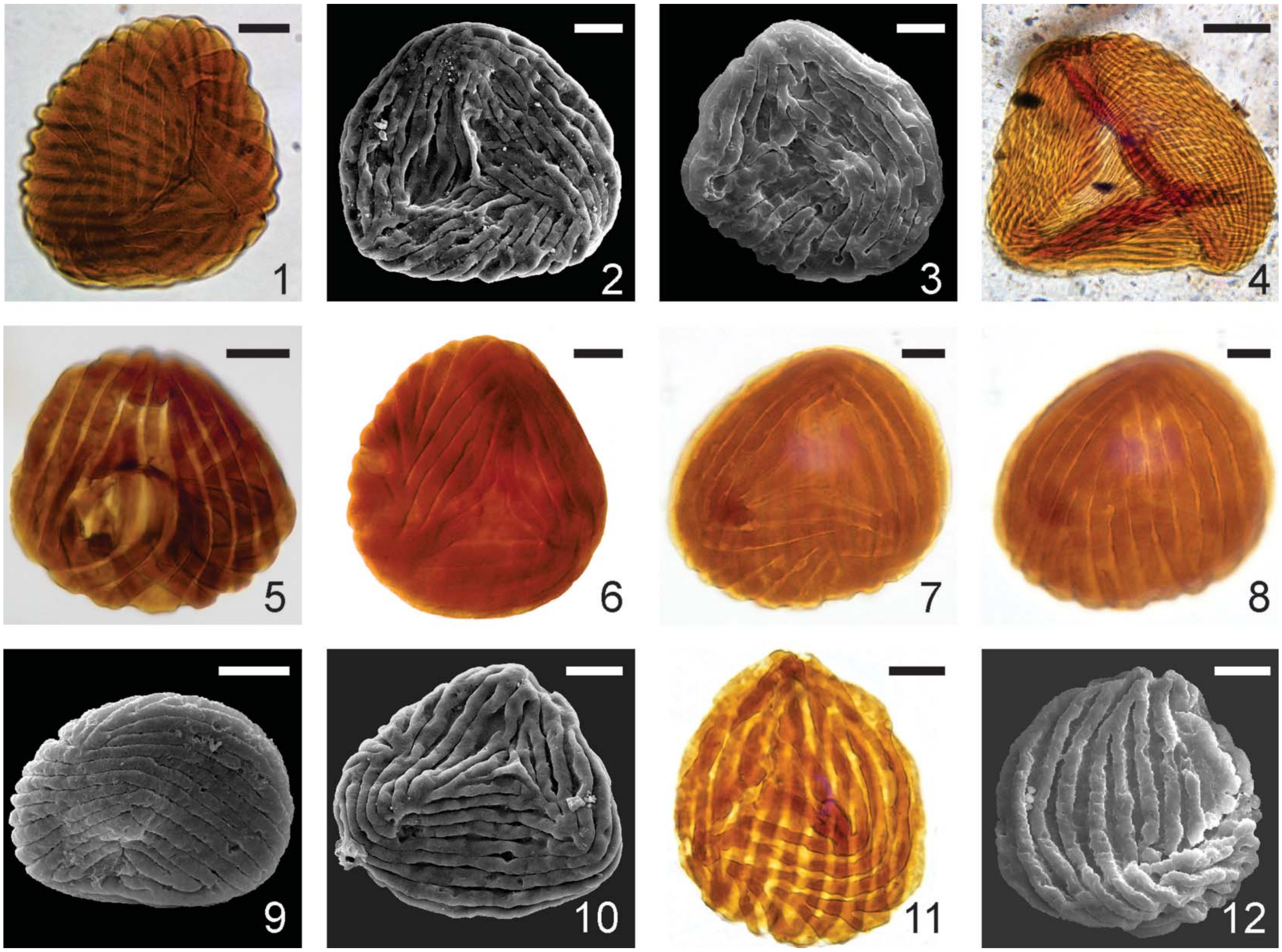

Plate 1. Figures 1–3. *Cicatricosisporites cuneiformis* Pocock 1964, Figure 1. 8449B: W34 MPLP, proximal view; Figure 2. MEB MACN; Figure 3. MEB LABMEM; Figure 4. *C. pramparoana* Archangelsky & Archangelsky 2010b, 5968F: L36/2 MPLP; Figure 5. *C.* sp. 1, 8435B: T21/1 MPLP, distal view; Figures 6–10. *Fisciniasporites* sp. cf. *F. brevilaesuratus* (Couper) Dettmann & Clifford 1992, Figure 6. 8436C: U41/2 MPLP, Figures 7–8. 8435D: X24/3 MPLP, Figure 9. MEB LABMEM, Figure 10. MEB MACN, proximal view (6–7, 9–10), distal view (8); 11–12. *F.* sp., Figure 11. 8449I: Y33/1 MPLP; Figure 12. MEB LABMEM. Scale bars 1–3 and 6–10: 10 μm; 4–5 and 11–12: 20 μm.

running parallel to the equator and coalescing in the disto-equatorial radial regions with the muri of the neighbouring series. Around the equator, a series 2–6 muri is arranged in spiral. Distal face with parallel to the subparallel muri, outer muri coalesce in two diametrically opposite subequatorial regions. Furrows 0.5–1 μm wide. A set of four muri and furrows at the distal face measures 12–20 μm across.

Dimensions. Equatorial diameter: 46–(62)–81 μm (32 specimens).

Studied material. La Yesera Formation: 8435D: C26/3, X24/3; 8435M: C28; 8435N: C28/1, C36; 8435P: Y33; 8435Q: F30; 8436B: F39, H42; 8436C: U41/2, V35/3; 8436D: L24/1; 8436G: C44/2; 8436I: H43/1; 8436S: Y34/2; 8449A: G28/1; 8449F: D32, M26; 8449G: F30/1; 8449K: T45/2 MPLP. 8435(2), 8449(5) SEM LABMEN; 8436(1), 8449(3) SEM MACN.

Comparison. *Fisciniasporites* sp. cf. *F. brevilaesuratus* shares most of the morphological features of *Cicatricosisporites annulatus* Archangelsky & Gamerro 1966, which also has an equatorial series of muri (see Archangelsky & Gamerro 1966). Nevertheless, *C. annulatus* has distinct smooth contact areas and in consequence only two series of muri in the spore (equatorial and distal), differing from the five series of muri that Dettmann and Clifford (1992) mentioned in the diagnosis of the genus *Fisciniasporites* (note the clearly ornamented proximal faces in our specimens: Plate 1, figures 6–7, 9–10).

Remarks. In the original description of *Cicatricosisporites brevilaesuratus*, Couper (1958) mentioned an equatorial diameter range of 70–(90)–120 μm and a muri width of 5–9 μm. However, Kemp (1970) emended the species based on material obtained from the same core sample

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studied by Couper. This author found that the size range and muri width were smaller (52–(72)–92 μm and 3–8 μm, respectively) and concluded that the overall size of Couper's specimens was due to swelling of the grains induced by prolonged oxidation.

The specimens here assigned to *F.* sp. cf. *F. brevilaesuratus* differ from the holotype described by Couper (1958) and later emended by Kemp (1970), in having rounded- (instead of flat-) topped muri.

Fisciniasporites sp.
Plate 1, figures 11–12

Description. Trilete spores, amb subcircular to triangular with convex sides and rounded angles. Laesurae simple, straight, 1/2 to 3/4 of the total length of the radius, distal face convex. Exine 0.5 μm thick, with canaliculate to cicatricose sculpture, muri of 6–10 μm width and 2–5 μm thick, straight, sometimes branching, solid. Proximal face with three series of 4–5 muri each, running parallel to the equator and coalescing in the disto-equatorial radial regions with the muri of the neighbouring series, an equatorial series arranged in spiral, and a distal series of parallel to subparallel muri with convergent outer muri that coalesce in two diametrically opposite subequatorial regions. Furrows 2–6 μm wide. A set of four muri and furrows on the distal face measures 33–42 μm across.
Dimensions. Equatorial diameter: 97–(103)–109 μm (4 specimens); polar diameter: 82 μm (1 specimen).
Studied material. La Yesera Formation: 8449I: Y33/1; 8449J: U41/2; 8449W: C37/2 MPLP; 8449(1) SEM LABMEN.
Comparison. These specimens are distinguished from *Fisciniasporites* sp. cf. *F. brevilaesuratus* described above, by their much larger size.

Genus *Nodosisporites* (Deák) Dettmann & Clifford 1992

Type species. *Nodosisporites costatus* Deák 1964

Nodosisporites sp.
Plate 2, figures 1–2

Description. Trilete spores, amb triangular with slightly convex sides and rounded angles. Laesurae with elevated lips (3–4 μm wide in the centre and reduced towards the ends), straight, 3/4 of the total length of the radius. Exine 0.5 μm thick, with cicatricose sculpture, muri of 2 μm width and 1.5 μm thick, straight to slightly sinuous, solid, bearing verrucae 1.5–3 μm wide and high, circular in planar view, sometimes with constriction at the base, irregularly spaced (2–5 μm). Proximal face with an inner smooth contact area surrounded by three series of 2–3 muri each, running parallel to the equator and coalescing in the disto-equatorial radial regions with the muri of the same series. Distal face not clearly observed, probably with muri parallel to equator. Furrows 3 μm wide. A set of four muri and furrows at the distal face measures ca. 20 μm across.
Dimensions. Equatorial diameter: 55 μm (1 specimen).
Studied material. Lagarcito Formation: 5968 F: N29/2 MPLP.
Comparison. The specimen from the Lagarcito Formation studied here is smaller than those described in the type species of the genus (*Nodosisporites costatus* Deák 1964, 63-68 μm). *Nodosisporites macrobaculatus* Archangelsky & Llorens 2005 has conspicuous baculae and clavae (up to 9 μm high), regularly distributed on both sides, but more densely in the proximal face. *Nodosisporites* cf. *N. genuinus* (in Archangelsky & Archangelsky 2010a) and *N. crenimurus* (Srivastava) Davies 1985; have supramural ornamentation consisting of spinae, coni and bacula. Our specimen also differs from the species previously recorded in Argentina in having a smooth contact area and sculptural elements unevenly distributed over the muri.
Remarks. The single specimen of *Nodosisporite*s sp. found in the Lagarcito Formation has a muri arrangement in the disto-equatorial radial region resembling that of *Ruffordiaspora*; see the characteristic notched angles in Plate 2, figure 2.

Genus *Ruffordiaspora* Dettmann & Clifford 1992

Type species. *Ruffordiaspora australiensis* (Cookson) Dettmann & Clifford 1992

Ruffordiaspora australiensis (Cookson) Dettmann & Clifford 1992
Plate 2, figure 3

Description. Trilete spores, amb triangular with straight to convex sides and notched angles. Laesurae simple, straight, reaching the equator. Exine 0.5 μm thick, with cicatricose to canaliculate sculpture, muri of 1.5–2 μm width and 1.5 μm thick, straight, sometimes branching, solid. Proximal face with three series of 4–5 muri each, running parallel to equator, and coalescing in the disto-equatorial radial regions with the muri of the same series. Distal face with three series of muri running parallel to each other, forming a triangle in the polar distal area. Furrows 1–2 μm wide. A set of four muri and furrows on the distal face measures ca. 14 μm across.
Dimensions. Equatorial diameter: 43–45 μm (2 specimens).
Studied material. Lagarcito Formation: 5861B: V33; 5968X: F33/4 MPLP.

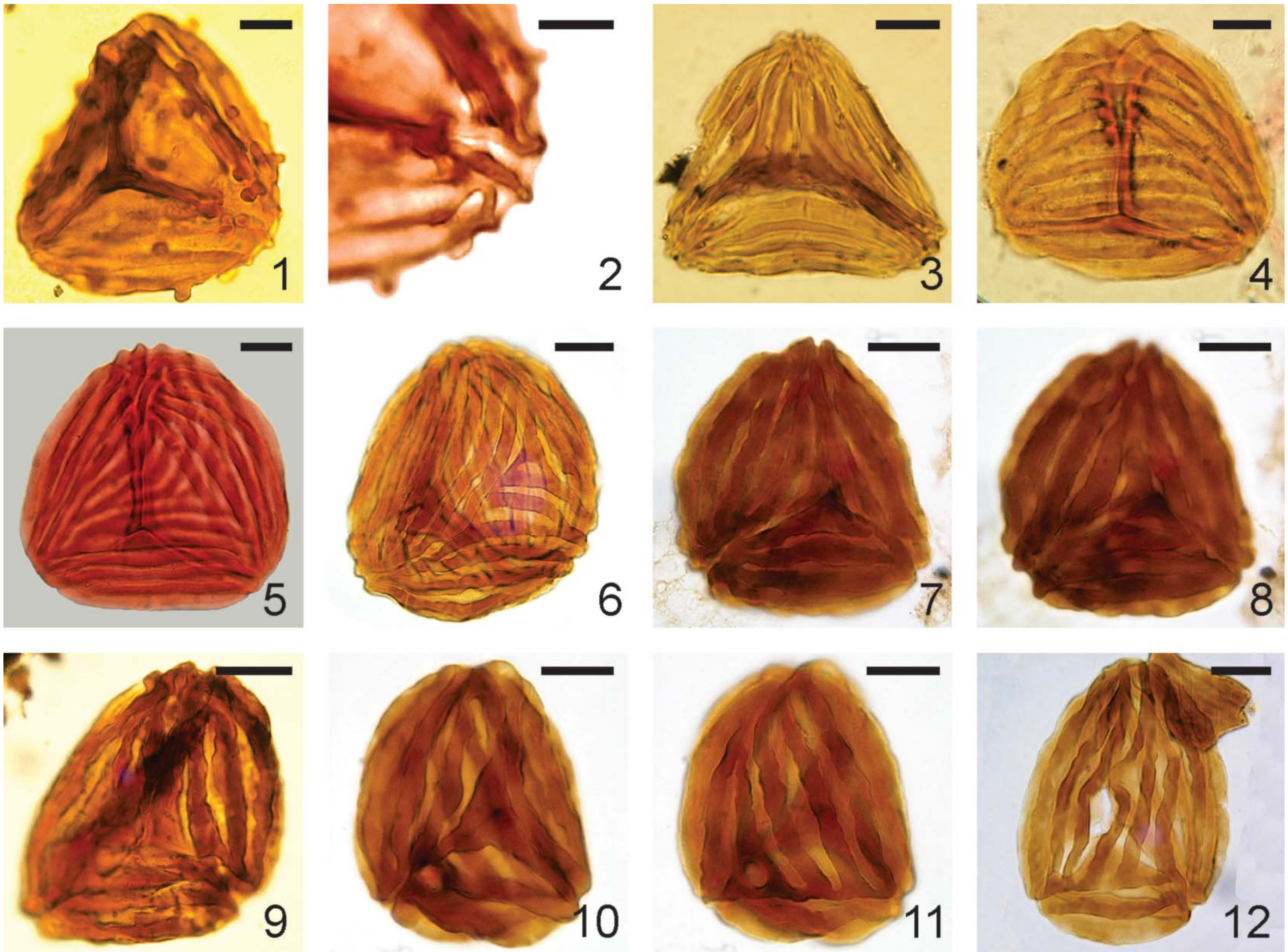

Plate 2. Figures 1–2. *Nodosisporites* sp., 5968F: N29/2 MPLP, Figure 1. proximal view, Figure 2. detail of the muri arrangement in the disto-equatorial radial region; Figure 3. *Ruffordiaspora australiensis* (Cookson) Dettmann & Clifford 1992, 5861B: V33 MPLP, proximal view; Figures 4–5. *R. cardielensis* Archangelsky & Archangelsky 2010b, Figure 4. 5968A: G53/3 MPLP, Figure 5. 5968J: D36/4 MPLP, proximal view; Figure 6. *R. ludbrookiae* (Dettmann) Dettmann & Clifford 1992, 8449H: G41/1 MPLP; Figures 7–9. *R.* cf. *ticoensis* Archangelsky & Gamerro) Archangelsky et al. 2008, Figures 7–8. 8449F: D42/4 MPLP, Figure 9. 8449W: K24/2 MPLP, proximal view (7, 9), distal view (8); Figures 10–12. *R.* sp. 1, Figures 10–11. 8449K: Q49/3 MPLP, Figure 12. 8449J: B47/4 MPLP, proximal view (10), distal view (11, 12). Scale bars 1, 3, and 4–5: 10 μm; 2: 5 μm; 6–12: 20 μm.

Comparison. *R. ludbrookiae* (Dettmann) Dettmann & Clifford 1992 has the same morphological features as the specimens studied, herein but larger dimensions (56–96 μm).

Remarks. According to Dettmann and Clifford (1992), the distribution of this species is still obscured by misidentifications; confirmed records indicate a wide geographical range during the Early and Mid Cretaceous. The species chronological range is Tithonian to Campanian (Dettmann & Clifford 1992), while in Argentina the stratigraphical distribution is Valanginian– Maastrichtian (Tables 2 and 3).

Ruffordiaspora cardielensis Archangelsky & Archangelsky 2010b
Plate 2, figures 4–5

Description. Trilete spores, amb subcircular to triangular with convex sides and notched angles. Laesurae straight, reaching the equator, sometimes with lips (1–3 μm wide). Most of the contact area smooth, distal face convex. Exine 0.5 μm thick, with cicatricose to canaliculate sculpture, muri of 1–3 μm width and 1–1.8 μm thick, straight to slightly sinuous, sometimes branching, solid. Proximal face with three series of 2–4 muri each, running parallel to the equator, and coalescing in the disto-equatorial radial regions with muri of the same series and generally separated from one another by a groove (or radial channel). Distal face with muri running parallel to the sides and forming a triangle in the distal pole. Furrows 1–4 μm wide. A set of four muri and furrows on the distal face measures 12–22 μm across.

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Dimensions. Equatorial diameter: 41–(48)–62 μm (16 specimens); polar diameter: 32 μm (1 specimen).
Studied material. Lagarcito Formation: 5861A: F36; 5861E: P40; 5968: M28/1; 5968A G35/3, N36; 5968B O31; 5968D 29/2; 5968H: P25, V23/4; 5968I: W32/3; 5968J: D21/3, D36/4, G38, V22/3; 5968O: T37/2; 6595A: L37 MPLP.
Remarks. Archangelsky and Archangelsky (2010b) described this species based on material from the Austral Basin in Argentina. They observed some intraspecific variability related to the diameter of the spores and the sinuosity of the muri. The diameter of the specimens collected in the San Luis Basin resemble those from the Bajo Comisión section in the Kachaike Formation (45–59 μm) (Archangelsky & Archangelsky 2010b).

Archangelsky and Archangelsky (2010b) indicated the resemblance of *Cicatricosisporites* sp. 4 and *C.* sp. 5 (in Archangelsky et al. 1983) to *R. cardielensis*.

Ruffordiaspora ludbrookiae (Dettmann) Dettmann & Clifford 1992
Plate 2, figure 6

Description. Trilete spores, amb triangular with convex sides and notched angles. Laesurae simple or sometimes with lips (up to 4 μm), straight, reaching the equator, distal face convex. Exine 0.5–0.8 μm thick, with canaliculate to cicatricose sculpture, muri of 1.5–7 μm width and 1.5–3 μm thick, generally straight, sometimes branching, solid. Proximal face with three series of 4–5 muri each, running parallel to equator and coalescing in the disto-equatorial radial regions with the muri of the same series. Distal face with three series of muri running parallel to each other, forming a triangle in the polar distal area. Furrows 1–6 μm wide. A set of four muri and furrows on the distal face measures 15–42 μm across.
Dimensions. Equatorial diameter: 59–(88)–110 μm (5 specimens).
Studied material. La Yesera Formation: 8449H: G41/1; 8449U: P38/2 MPLP. Lagarcito Formation: 5861D: W34; 5968J: E21/0; 5968K: J30/2 MPLP.
Comparison. *R. australiensis* has the same morphological features as *R. ludbrookiae* but it is smaller (36–70 μm) (Dettmann 1963; Dettmann & Clifford 1992).
Remarks. Archangelsky & Archangelsky (2010b) transferred *Appendicisporites* sp. A Volkheimer & Quattrocchio 1975 to *R. ludbrookiae*. The specimen represents the oldest record of cicatricose spores in Argentina (Tithonian, Vaca Muerta Formation in the Caichugüe area, Neuquén Basin).

According to Dettmann and Clifford (1992), the range of *R. ludbrookiae* is Tithonian–Albian. In Argentina, this species has been recovered from the Tithonian to Albian (Table 2).

Ruffordiaspora cf. *R. ticoensis* (Archangelsky & Gamerro) Archangelsky et al. 2008
Plate 2, figures 7–9

Description. Trilete spores, amb triangular with slightly convex sides and notched angles. Laesurae simple, straight, reaching the equator, distal face convex. Exine 0.5–0.8 μm thick, with canaliculate to cicatricose sculpture, muri of 5–8 μm width and 2 μm thick, straight to slightly sinuous, solid. Proximal face with three series of 3 muri each, running parallel to the equator, and coalescing in the disto-equatorial radial regions with the muri of the same series. Distal face with three series of muri running parallel to each other, forming a triangle in the polar distal area. Furrows 1–5 μm wide. A set of four muri and furrows on the distal face measures 30–40 μm across.
Dimensions. Equatorial diameter: 78–85 μm (2 specimens).
Studied material. La Yesera Formation: 8449F: D42/4; 8449W: K24/2 MPLP.
Remarks. The cf. designation refers to the presence of three muri in each set on the proximal face, while *R. ticoensis*, has only one or two. Our specimens are similar to *Cicatricosisporites apicanalis* (Paden Phillips & Felix 1971) which Archangelsky & Archangelsky (2010b) considered a synonym of *R. ticoensis*.

Ruffordiaspora sp. 1
Plate 2, figures 10–12

Description. Trilete spores, amb triangular with straight to convex sides and notched angles. Laesurae simple or with margo (up to 12 μm), straight, reaching the equator, distal face convex. Exine 0.5–0.8 μm thick, with canaliculate to cicatricose sculpture, muri of 4–10 μm width and 2–3 μm thick, straight to slightly sinuous, solid. Proximal face with three series of 2–4 muri each, running parallel to the equator, and coalescing in the disto-equatorial radial regions with the muri of the same series. Distal face with muri diverging from one corner, bifurcating and running more or less parallel, covering most of the distal face, and reaching a set of 1–2 distal muri running parallel to the opposite side. Furrows 3–7 μm wide. A set of four muri and furrows on the distal face measures 32–53 μm across.
Dimensions. Equatorial diameter: 74–(88)–100 μm (5 specimens); polar diameter: 92 μm (1 specimen).
Studied material. La Yesera Formation: 8449D: X40/2; 8449I: V39/2; 8449J: B47/4; 8449K: Q49/3; 8449L Q31/2 MPLP.
Comparison. *Cicatricosisporites myrtellii* Burger 1966 has an equal muri arrangement on both faces, but is

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smaller (35–45 μm) with thinner muri (3–4 μm) and furrows (1 μm).

The specimens of *R.* sp. 1 share all the morphological features with *Ruffordiaspora* cf. *R. ticoensis* already mentioned, except from the different muri pattern on the distal face and wider furrows.

4. Results

Cicatricose spore records in Argentina are summarized in Table 2. Four genera (*Cicatricosisporites*, *Fisciniasporites*, *Nodosisporites* and *Ruffordiaspora*) and 11 species of cicatricose spores are described from samples from outcrops of the La Yesera and Lagarcito formations in north and central-western Argentina (Figure 1; Table 2). The cicatricose genera *Plicatella* and *Palaeomohria* are absent from these associations. In the San Luis Basin, *Appendicisporites* is present only in the La Cantera Formation (Prámparo 1989; Table 2), and *Nodosisporites* in the Lagarcito Formation (this paper). The presence of *Fisciniaesporites* in Argentina is confirmed with the specimens from the La Yesera Formation (Table 2).

The associations from the formations studied in the Salta Group and San Luis basins have similar species richness (seven and nine respectively, both with three genera; Table 2). However the Lagarcito Formation has a lower percentage of cicatricose spores when considering the whole assemblage (2–16%), while in the La Yesera Formation, the abundance of this type of spore reaches 54.2% in one of the assemblages from the Don Bartolo Member (sample 8449 MPLP; Narváez 2009). This is probably related to the more humid subtropical conditions prevailing during the deposition of the La Yesera Formation (Sabino 2002), in comparison with the arid to semi-arid environment at the time of the deposition of the Lagarcito Formation (Chiappe et al. 1998; Rivarola & Spalletti 2006).

5. Discussion

Schizaealean spores with cicatricose ornamentation prevailed worldwide during the Late Mesozoic, particularly in the Aptian and Albian (Archangelsky 2009). The Mid-Cretaceous rise in the relative diversity of the Anemiaceae (*sensu* Smith et al. 2006) and Gleicheniaceae in Australia for example, was first noted by Dettmann and Playford (1969) and later confirmed quantitatively by Nagalingum et al. (2002). In Argentina, the rise in diversity of cicatricose spores during the Aptian–Albian is also evident, as it can be observed in the distribution of species from the Cretaceous assemblages (Table 3).

Currently, there are approximately 120 species of *Anemia* distributed in tropical and subtropical areas. In Argentina, the three families that constitute the order Schizaeales have one genus each: Anemiaceae (*Anemia*), Lygodiaceae (*Lygodium*) and Schizaeaceae (*Schizaea*). Amongst them, *Anemia* is present in north and central-western Argentina, including Salta, San Luis and San Juan provinces (Martínez et al. 2003; Zuloaga et al. 2008; Arana & Bianco 2011). *Mohria* is presently restricted to Madagascar, South Africa, Mozambique and the adjacent Mascarene Islands (Tryon & Lugardon 1991). Ramos Giacosa et al. (2012) made a thorough study of spore morphology and wall ultrastructure of the nine *Anemia* species present today in Argentina. Five of them have canaliculate sculpture and muri ornamentation consisting of small spines (0.2–4.5 μm high), while the other four have cicatricose sculpture and muri ornamentation comprised of bacula (1.6–8.3 μm high).

In Argentina, the oldest records of cicatricose spores correspond to *Ruffordiaspora* (Tables 2 and 3; Volkheimer & Quattrocchio 1975). Dettmann and Clifford (1992) indicated that *Ruffordia*-type spores were distributed in both hemispheres by the Late Jurassic, then were restricted to middle and high latitudes during the Early Cretaceous, and became extinct by the end of the Cretaceous. On the other hand, *Anemia*-type spores had a near worldwide distribution by the Early Cretaceous, and progressively contracted since the Late Cretaceous to reach their present distribution in tropical America, Africa and southern India (Dettmann & Clifford 1992). The oldest records of *Cicatricosisporites* in Argentina correspond to the Valanginian–Hauterivian Agrio Formation (Prámparo & Volkheimer 1999; Tables 2 and 3). According to Dettmann and Clifford (1992), there are no confirmed pre-Cretaceous occurrences of this genus in the high latitudes of southern Gondwana.

Dettmann and Clifford (1992) suggested that *Cicatricosisporites* sp. 1 from the La Cantera Formation (Prámparo 1989) may be attributable to *Fisciniasporites*. However, we restudied the original specimen described by Prámparo (1989) and found that one of the proximal series of muri continues through the distal face, therefore confirming its original assignation to the genus *Cicatricosisporites*. Moreover, and as previously mentioned, *Cicatricosisporites annulatus* Archangelsky & Gamerro 1966 has a distinct equatorial series of muri, but a reassignation to *Fisciniaesporties* is not possible due to the absence of the three proximal series that are also diagnostic of this genus.

Fisciniasporites sp. cf. *F. brevilaesuratus*, with its series of five muri, is one of the most representative species in assemblages from the La Yesera Formation, coincident with associations from Brazil where it was also recorded in the Santana Formation (Lima 1978). The confirmed presence of *Fisciniasporites* in South America (Tables 1 and 2) during the Early Cretaceous expands the geographical distribution of this genus that was previously thought to be restricted to the Northern Hemisphere (Dettmann & Clifford 1992).

The age range of *Nodosisporites* in Antarctica is Albian–Santonian (*Nodosisporites crenimurus*; Dettmann & Thomson 1987; Barreda et al. 1999). In Argentina, besides our specimen of *N.* sp., three species were mentioned from Aptian–Albian strata of the Austral Basin (Archangelsky & Llorens 2005; Archangelsky & Archangelsky 2010a; Perez Loinaze et al. 2012). The youngest records of the genus correspond to Cenomanian sediments from the San Jorge (Archangelsky et al. 1994) and Austral basins (Archangelsky & Archangelsky 2010a) (Table 2).

Based on palynological studies from Australian sediments, Helby et al. (1987) defined the *Cicatricosisporites australiensis* Interval Zone for the Berriasian and the *Appendicisporites distocarinatus* Oppel Zone for the Late Albian-Cenomanian. Recently, Wagstaff et al. (2012) proposed the *Cicatricosisporites cuneiformis* Subzone within the *Coptospora paradoxa* Zone (Dettmann & Playford 1969) for the Albian in Australia. They placed the top of this subzone, and the top of *C. paradoxa* Zone at 103.5Ma (Albian). In Argentina, *C. cuneiformis* was mentioned not only in this contribution from the La Yesera Fomation (Albian–Cenomanian) but also in the Austral Basin (Late Aptian to Cenomanian; Archangelsky et al. 2008; Medina et al. 2008; Archangelsky & Archangelsky 2010a, 2010b; Perez Loinaze et al. 2012; Table 2). Therefore, it could be considered as a very useful biostratigraphical marker for the Late Aptian–Cenomanian in Argentina.

Regarding the Cretaceous palynological zones defined by cicatricose species at low latitudes of the Southern Hemisphere, Coimbra et al. (2002) created the Upper Aptian/Albian *Cicatricosisporites avnimelechi* Zone, which occurs in the middle Ipubi and upper Romualdo members of the Santana Formation, as well as in the Upper Arajara Formation of Brazil. So far *C. avnimelechi* Horowitz 1970 has not been found in any Cretaceous Argentinian assemblages. However, it is important to highlight that in the original description of the species there is no mention of the muri arrangement, which poses a problem for making comparisons.

Taking into account that many studies only show a listing of species, further revision is needed in order to provide more accurate descriptions that may correct misidentified taxa. Such work is important considering the potential biostratigraphical significance of some taxa within the cicatricose spores from the southern part of South America.

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Appendix 1

List of the palynomorph species studied from the La Yesera and Lagarcito formations.

Cicatricosisporites cuneiformis Pocock 1964
Cicatricosisporites pramparoana Archangelsky & Archangelsky 2010b
Cicatricosisporites sp. 1 (in this paper)
Fisciniasporites sp. cf. *F. brevilaesuratus* (Couper) Dettmann & Clifford 1992
Fisciniasporites sp.
Nodosisporites sp.
Ruffordiaspora australiensis (Cookson) Dettmann & Clifford 1992
Ruffordiaspora cardielensis Archangelsky & Archangelsky 2010b
Ruffordiaspora ludbrookiae (Dettmann) Dettmann & Clifford 1992
Ruffordiaspora cf. *R. ticoensis* (Archangelsky & Gamerro) Archangelsky et al. 2008
Ruffordiaspora sp. 1 (in this paper)

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