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PRELIMINARY STUDIES OF DEVONIAN MICROFLORAS OF A BOREHOLE FROM THE TARIJA BASIN, NORTHWESTERN ARGENTINA

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INTRODUCTION

Devonian deposits in the southern Tarija Basin crop out mainly in the western Subandean Range to the eastern part of the Cordillera Oriental of Argentina and are widely distributed from the northernmost of Argentina to Bolivia. In contrast, Devonian subsurface deposits extend over between Bolivia, Paraguay and Argentina. They are represented by shale and sandstone facies deposited mainly in a shallow marine environment; less significant are littoral and continental facies that contain palaeontological evidences of having been connected with other coeval close deposits in Brazil, Peru, Uruguay especially during transgressions (Fig. 1; Melo, 1989; Starck, 1996; Limachi *et al.*, 1996). Subandean zone, in this basin is a thin-skinned thrust belt characterized by elongated anticlines that run north-northeast–south-southwest, forming several continuous, and parallel ranges (Echavarria *et al.*, 2003, and references therein). One of them is called San Antonio, where the borehole San Antonio X-1 is located. Most of the knowledge on Devonian successions from the Tarija Basin comes from subsurface data, from petroleum boreholes drilled during the pasts decades (see Limachi *et al.*, 1996). The Los Monos Formation and its Argentinean equivalent, the Tonono Formation, range from the latest Eifelian or early Givetian through the early Frasnian (Melo, 2005 a, and references therein). This work presents a preliminary palynological survey of a Devonian microflora recovered from the Los Monos Formations in the San Antonio X-1 well in the Tarija Basin, northwestern Argentina.

COMPOSITION AND AGE OF THE ASSEMBLAGES

The San Antonio X-1 well was drilled to a maximum depth of about 3600 m (15700 feet). A hundred and fifty seven cutting samples were collected, around each seven meter depth along 1100 m of the borehole. Twenty-three samples were selected and processed for a preliminary overview, with an average distance of thirty-seven meters in between each one. The microflora recovered is composed of 68 species relatively well-preserved which is represented by diverse palynological groups such as trilete spores (34

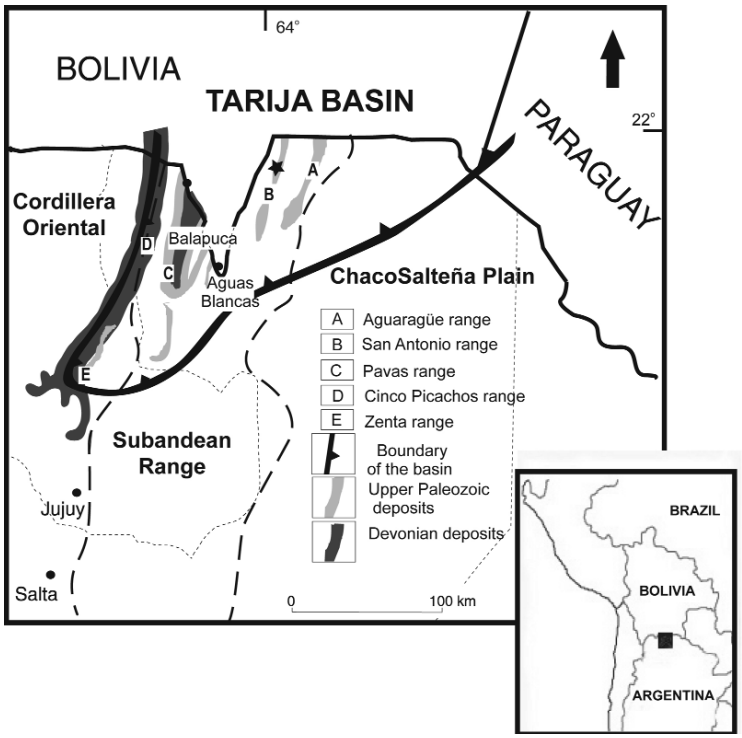

Figure 1. Southern Tarija Basin (Northwestern Argentina) with the location of the San Antonio x-1 well (star).

species), cryptospores, palaeomicroplankton including several Prasinophycean (e.g., *Cymatiosphaera*, *Duvernaysphaera*, *Maranhites*, *Polyedrixium*, *Pterospermella*, *Hemiruptia*, *Leiosphaeridia*) and acritarchs taxa (29 species), the chlorophycean algae *Chomotriletes* and *Quadrisporites*, chitinozoans (5 species) and scolecodonts. Some of these species are new taxa that need to be described. Quantitative information about major groups is displayed in Figure 2. The stratigraphic distribution of the species allowed to distiguish three associations (Table 1).

The **palynoassemblage A3** (Fig. 2; Table 1) is characterized by trilete spores and a high palaeomicroplankton diversity represented mainly by acritarchs and prasinophytes (57% of the total) while the chitinozoans are less frequent (8%). Many species are exclusive to this assemblage such as *Verrucosisporites bulliferus* (Taugourdeau-Lantz) Richardson and McGregor, *Ammonidium garrasinoi* Ottone, *Umbellasphaeridium deflandrei* (Moreau-Benoit) Jardiné *et al.*, *Stellinium micropolygonale* (Stockmans and Willière) Playford, *Pseudolunulidia laevigata* Brito and Quadros, *Belonechitina holfeltzii* Ottone, *Angochitina galarzae* Ottone and *Maranhites mosesii* (Sommer) Brito emend. Burjack and Oliveira, the latter, also present in A2. The presence of different species of *Maranhites* is typical from the Late Devonian assemblages in Bolivia, Brazil and Argentina (e.g., Ottone, 1996; Limachi *et al.*, 1996; Quadros, 1999). Most of the species in A3 are registered in the upper section Los Monos Formation (northwestern Argentina) by Ottone (1996 and references therein) attributed to the late Givetian – early Frasnian. Moreover, *Lunulidia micropunctata* Pöthe de Baldis and *Maranhites brasiliensis* Brito emend. Burjack and

Oliveira were recorded in the Frasnian Ponta Grossa Formation of the Paraná Basin (Quadros, 1999). The presence of *Verrucosisporites bulliferus* that has been quoted in the early Frasnian of northwestern Argentina (Ottone, 1996) as well as in Bolivia (Pérez Leyton, 1991; Vavrdová *et al.*, 1996) and Brazil (Melo, 2005 b), allow to attribute the same age to our association.

The **palynoassemblage A2** (Fig. 2; Table 1) comprises predominantly continental elements (91%) while the other taxa are strongly subordinated (Fig. 2). Pseudosaccate spores of the genus *Grandispora* are dominant and especially *Grandispora pseudoreticulata*, endemic of the Middle to Late Devonian of South America (di Pasquo *et al.*, 2007). Even though *Geminospora lemurata* (Balme) Playford, which appears in the earliest Givetian of Euramerica (see Richardson and McGregor, 1986), was not registered, *Verrucosisporites scurrus* (Naumova) McGregor and Camfield, *Samarisporites* sp., *Acinosporites macrospinosus* Richardson, *Acinosporites ledundae* Ottone, *Dibolisporites farraginis* McGregor and Camfield, *Cymbosporites catillus* Allen, *Leiotriletes balapucencis* di Pasquo, *Chomotriletes vedugensis* Naumova, and *Biharisporites parviornatus* Richardson are shared with the Association 2 of Middle-Late Givetian age at Balapuca (Los Monos Formation, di Pasquo, 2007), and correlate both assemblages. Regarding on the presence of *Ramochitina ramosi* Sommer and van Boekel, quoted for the late Eifelian-middle Givetian of the Paraná Basin (Grahn *et al.*, 2002) and due to the fact that there are not exclusive Eifelian taxa registered; we propose a Givetian age to this assemblage.

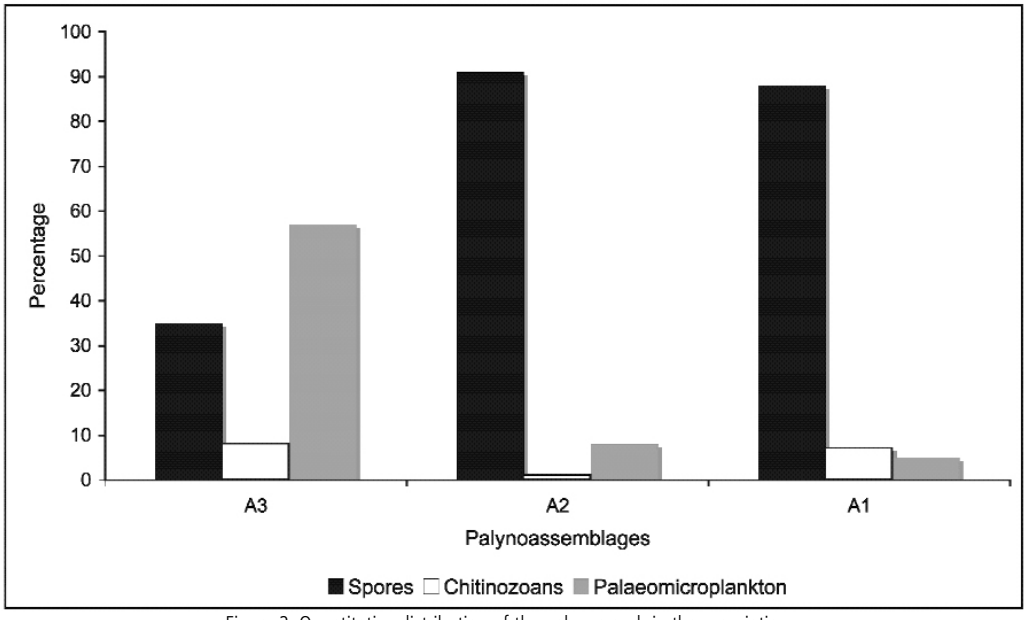

Figure 2. Quantitative distribution of the palynomorph in the associations.

The **palynoassemblage A1** (Fig. 2; Table 1) is composed mostly of continental elements (88%). Strong markers occurring in this section are: *Verrucosisporites loboziakii* Marshall and Fletcher quoted for the Eifelian of the Orcadian Basin (Marshall and Fletcher, 2002) together wih other Euramerican index taxa such as *Grandispora douglastownense* McGregor that appears in the *Grandispora douglastownense – Ancyrospora eurypterota* Assemblage Zone (Late Emsian and earliest Eifelian) following in the

Sample depths / Palynomorph taxa	2572-2580 m	2582-2592 m	2594-2600 m	2602-2610 m	2690-2698 m	2734-2740 m	2836-2848 m	2904-2914 m	2990-2996 m	3030-3036 m	3078-3088 m	3124-3134 m	3164-3166 m	3200-3210 m	3284-3298 m	3332-3346 m	3398-3408 m	3446-3456 m	3494-3504 m	3534-3548 m	3584-3598 m	3610-3616 m	3620-3628 m
Belonechitina holfeltzii	x	x	x																				
Grandispora pseudoreticulata	x	x	x		x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x
Maranhites mosesii	x	x	x	x	x	x		x															
Multiplicisphaeridium ramusculosum	x	x	x																				
Navifusa bacillum	x	x	x	x	x																		
Pterospermella pernambucensis	x	x	x	x	x	x																	
Verrucosisporites scurrus	x	x	x	x	x	x			x		x	x							x				
Veryhachium trispinosum	x	x	x	x	x	x																	
Ammonidium garrasinoi	x	x																					
Angochitina galarzae	x	x																					
Grandispora daemonii	x	x						x															
Leiosphaeridia sp.	x	x		x							x												
Leiotriletes balapucencis	x	x				x	x		x		x	x		x						x		x	x
Muraticavea munificus	x	x																					
Quadrisporites granulatus	x	x					x	x	x											x			
Acinosporites lendudae	x		x	x	x		x	x	x	x	x								x				
Pseudolunilinida laevigata	x		x																				
Quadrisporites variabilis	x		x		x														x		x		
Ancyrospora sp.	x									x	x												
Evittia remota	x																						
Grandispora riegelii	x						x	x	x	x	x	x						x					x
Leiotriletes pagius	x			x			x	x						x	x	x					x		
Retusotriletes paraguayensis	x					x	x						x					x					
Stellinium micropolygonale	x																						
Tunisphaeridium caudatum	x																						
Umbellasphaeridium deflandrei	x																						
Veryhachium trisulcum	x																						
Cymatiosphaera sp.		x																					
Duvernaysphaera angelae		x																					
Duvernaysphaera tenuincingulata		x		x																			
Grandispora inculta		x		x										x									
Hemiruptia legaultii		x		x	x	x																	
Lunulidia micropunctata		x																					
Verrucosisporites bulliferus		x			x																		
Duvernaysphaera tesella			x																				
Maranhites brasiliensis			x																				
Dibolisporites echinaceus				x								x					x		x	x		x	
Biharisporites parviornatus					x				x	x	x										x		
Dibolisporites uncatus						x							x		x								x
Samarisporites sp.						x																	
Emphanisporites rotatus							x	x					x	x		x	x		x	x			x
Dyadospora sp.							x			x		x									x	x	
Cymbosporites catillus								x	x	x	x												
Chomotriletes vedugensis								x															
Acinosporites macrospinosus									x														
Dibolisporites farraginis									x														
Ramochitina ramosi									x				x										
Cyclogranisporites plicatus										x	x	x	x				x						x
Apiculatasporites microconus													x								x		
Dibolisporites eifeliensis													x										
Verrucosisporites loboziakii													x								x		
Grandispora douglastownense															x							x	
Emphanisporites epicautus																x							
Densosporites inaequus																	x	x					
Acinosporites lindlarensis																	x						
Granulatisporites muninensis																		x					
Grandispora protea																			x		x		x
Hystricosporites sp.																			x				x
Corystisporites multispinosus																							x

Table 1. Stratigraphical distribution of selected palynomorphs (in last occurrence order) present in the San Antonio X-1 borehole. Palynoassemblages A3 (early Frasnian), A2 (Givetian) and A1 (Middle to Late Eifelian) are painted in orange, green and blue, respectively.

Densosporites devonicus – *Grandispora naumovii* Assemblage Zone (Mid-Eifelian to Early Givetian), and *Dibolisporites eifeliensis* (Lanninger) McGregor, *Densosporites inaequus* (McGregor) McGregor and Camfield and *Corystisporites multispinosus* Richardson that are recorded from the Eifelian and lower Givetian (see Richardson and McGregor, 1986). On the basis of these ranges and regarding on the fact that most of these taxa are also recognized in the Association 1 attributed to the Late Eifelian by di Pasquo (2007), we suggest a Middle to Late Eifelian age to our assemblage 1.

PALAEOENVIRONMENTAL AND FINAL CONSIDERATIONS

There is no evidence for intraformational contamination due to the drilling, supported by the fact that taxa like *Veryhachium* spp. and *Maranhites* spp., abundant in the upper levels, do not appear further down together with asserted indigenous species. The Los Monos Formation was mainly interpreted to characterize offshore facies (Limachi *et al.,* 1996). The data displayed above, show strong evidence for palaeoenvironmental changes during the deposition of the succession. It is likely that the low proportion of marine elements in the A1 and A2 are coincident with a drop in the sea level, a tendency that Albariño *et al.* (2002) registered from the Early Eifelian and appears to continue along the Givetian (assemblage A2), towards the end of this period and mainly in the Early Frasnian, the increase of palaeomicroplankton in the assemblage 3, supports a new transgressive cycle. Finally, it is outstanding as well, to state that there are several common species recorded in the Argentinean Precordillera that reinforce the connection of both marine and continental areas during the Middle Devonian (Amenábar, 2007; di Pasquo *et al*., 2007, and references therein).

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