STATE OF THE ART OF THE DEVONIAN PALYNOLOGICAL RECORDS IN NORTHERN ARGENTINA, SOUTHERN BOLIVIA AND NORTHWESTERN PARAGUAY

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Introduction

The Devonian rocks in the north of Argentina crop out in the Subandean and the Santa Barbara ranges and extend into the subsurface of the Chaco-Salteña Plain. They were part of the Tarija Basin that includes the center and the south of Bolivia and the northwest of Paraguay (figure 1). This basin would have been interconnected with other neighboring basins like the Arizaro basin, extended in the north of Chile and the Argentinean Puna, the Madre de Dios basin in the north of Bolivia and the south of Peru and other basins of the west of Brazil based on common paleontological records (see Grahn, 2005). Besides, the generally thick Devonian layers in the Tarija Basin mainly composed of sandstones and pellites (rich in organic matter), are broadly distributed and related to deposits of petroleum and gas. So, this basin has been studied mainly with exploratory aims and many multidisciplinary works based on subsurface and surface information belong to the involved oil companies. In contrast, there are less published multidisciplinary works (e.g., Vistalli, 1999; Suárez Soruco, 2000; Albariño *et al.*, 2002; Alvarez *et al.*, 2003) and it is the same with palynological ones as explained below.

Some comments about Devonian palynology

Several palynostratigraphical schemes related to the hydrocarbon exploration were defined (e.g., Suárez Soruco and Lobo Boneta, 1983; Súarez Soruco, 1989; Limachi *et al.*, 1996), based on an important number of mainly unpublished palynological studies of subsurface and surface, but they consist only of a limited list of species by zone, non-illustrated and some of them without specific assignment. Biostratigraphy often represent the evolution of the biota in a certain region, and it can be established in different ways; the most frequent forms are the *assemblage zone* based on a set of species, and the *interval zone* related to the successive appearance/disappearance of key species. These schemes can be influenced or controlled by paleogeography, so assemblages may be dominated by species of marine origin in some places, in contrast to other assemblages composed of species of continental origin. This is the main reason that prevents the use of the same biostratigraphical scheme in different places in the same basin and many times it is difficult to establish a suitable correlation between zones based on marine versus continental taxa like the Grahn‘s (2002, 2005) chitinozoan biostratigraphy. Moreover, in some cases a zone is characterized with very few species (e.g., *Crucidia camirense*). Additionally, the subjective selection of key species, the lack of enough publications with illustrated species, and of course, the existence of endemic species that cannot be used properly with biostratigraphical meaning due to they were not defined yet are other remaining problems in the Devonian biostratigraphy of the Tarija Basin that need to be solved. On the other hand, systematic or palynostratigraphical works with illustrated lists of species (spores, acritarchs and/or chitinozoans), from the south of Bolivia correspond to Lobo Boneta (1975), Kimyai (1983), McGregor (1984), Pérez Leyton (1990, 1991), Blieck *et al.* (1996), Grahn (2002, 2005), di Pasquo (2007 to, b). From the northwest of Argentina they were published by Volkheimer *et al.* (1983, 1986), Barreda (1986), Ottone (1996), Grahn and Gutierrez (2001), Grahn (2002) and from northwest Paraguay by Menéndez and Pöthe de Baldis (1967) and Pöthe de Baldis (1974, 1979). Some of these works require to be updated and they are insufficient to know the evolution of the microfloras in this Gondwana region and to allow

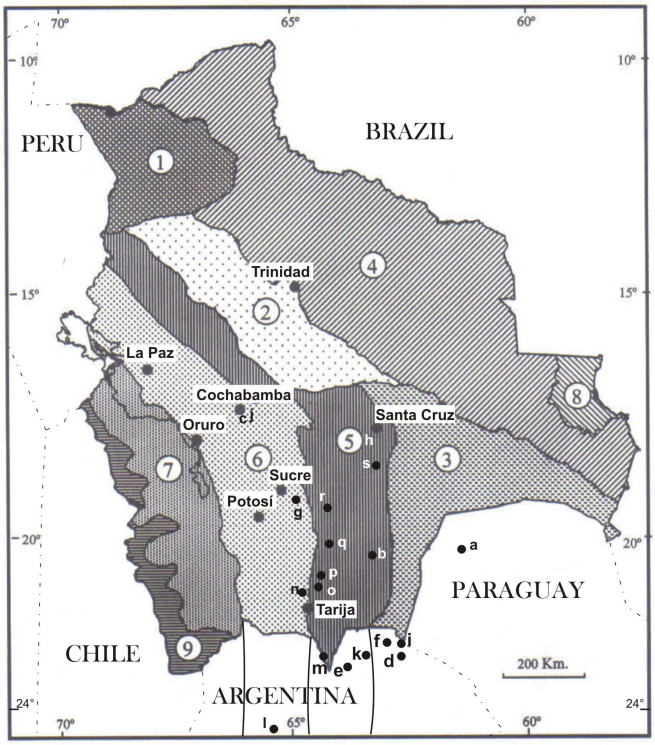
the application with certainty of the biostratigraphical schemes to new localities and to establish more accurate comparisons and correlations with other microfloras of the rest of the World.

With respect to the stratigraphical units bearing the palyno-associations, it has been recognized and sometimes published that the same association can appear in different units previously attributed to different ages if any paleontological information was known for its dating and correlation (e.g., Melo, 2005). The recent finding of an Early Carboniferous (early Visean) assemblage in the diamictites of the Itacua Formation at Balapuca (di Pasquo, 2007 a, b), constitutes a first approach to study in detail and to date this unit (and its correlative Saipurú Formation) at new sections that would help to solve its stratigraphical relation with the underlying Devonian layers. In this sense, the recognition of reworked palynomorphs in this assemblage (several illustrated), was very important to define accurately the age of the native association. The age of the assemblage at the top of the Los Monos Formation underlying the Itacua Formation, allow to define the time of the hiatus. The analysis of the stratigraphical ranges of reworked species and the absence of certain key species such as *Retispora lepidophyta* were used to establish that this hiatus could be partially depositional and non-depositional, but this would be variable at different localities (di Pasquo, 2007 a, b). Two possible localities with assemblages that were interpreted as *Rl* association (late Famennian) correspond to the Picuiba borehole (Pöthe de Baldis, 1974, 1979) and to the Bermejo river (Pérez Leyton, 1990) and are depict in figures 1 and 2. Nevertheless, in both associations a great diversity of spores, acritarchs and chitinozoans species are present. Moreover, *Botryococcus* is registered as well, along with numerous spore species of *Densosporites*, *Cristatisporites* and *Convolutispora* genera, which are more frequent to abundant in the Carboniferous assemblages than in the Devonian ones in the World. Actually, Pérez Leyton (1990, 1991) recognized the presence of some species such as *Colatisporites decorus* and *Cristatisporites echinatus* whose previous records in Euramerica and Australia indicate with certainty Early Carboniferous age as it was discussed by di Pasquo and Azcuy (1997). These authors illustrated some species of the Devonian and Early Carboniferous recovered from Upper Carboniferous deposits (Macharetí and Mandiyutí Groups), and reinterpreted the age of the assemblages recovered from Saipurú Formation by Lobo Boneta (1975) and Pérez Leyton (1990, 1991) as Early Carboniferous based on the separation of indigenous and reworked palynomorphs. Grahn (2005) recognized that at the end of the Famennian when a glaciation took place, the chitinozoans disappeared from western Gondwana in the *Vallatisporites hystricosus* (VH) Interval spore Zone Melo and Loboziak (2003) before the *Retispora lepidophyta – Vallatisporites vallatus* (Lva) Interval spore Zone Melo and Loboziak (2003). So, this evidence can support the above reinterpretation of the Saipurú Formation age. It is important to emphasise that in the Amazon Basin (north Brazil), as well as in the Madre de Dios Basin (north of Bolivia) reworked palynomorphs have been recognized in *Retispora lepidophyta* assemblages (see Melo and Loboziak, 2003). Besides, the appearance of palynomorphs of different ages in the Upper Carboniferous deposits is a recurrent matter in the Tarija Basin and it is also known to occur within the Devonian ones.

Conclusions

The correlation of the different biostratigraphical schemes proposed for the Devonian of Tarija Basin shows a relative diachronic relation between some zones, which can be explained as the knowledge of the Devonian microfloras is still precarious. Detailed systematical and stratigraphical works embracing all palynomorphs (spores, acritarchs and chitinozoans) in different localities of the basin are recommended to carry out as they will allow establishing better correlations between mostly marine and continental assemblages. An accurate analysis of the previous records of all the species recognized in the diamictites attributed to the Itacua Formation at Balapuca was used to separate the possible reworked forms from the native group, and thus it was useful to prevent a wrong interpretation of the age and the palaeoenvironment of the deposit. Additional data, however, are needed to further improve the evolution of the Devonian microfloras and their palaeobiogeographical distribution and to better understand the stratigraphy of the D-C boundary in the region and the causes of the palaeogeographical and palaeoclimatical changes that have controlled the microfloras evolution in that time in the west of Gondwana.

Figure 1. Geological Provinces of Bolivia and north of Argentina (after Suárez Soruco, 2000). References: 1- Madre de Dios, 2- Beni, 3- Chaco and Llanura Chaco-Salteña, 4- Cratón de Guaporé, 5- Subandinas (north and south), 6- Cordillera Oriental, 7- Altiplano, 8- Pantanal, 9- Cordillera Occidental. Localities: a- Picuiba borehole (Menéndez and Pöthe de Baldis, 1967; Pöthe de Baldis, 1974, 1979), b- Camirí and Azero river (Lobo Boneta, 1975), c- Borehole at Cochabamba (Kimyai, 1983), d- Puesto El Tigre, e- Ramos and f- Tonono boreholes (Volkheimer *et al.*, 1983, 1986), g- Tarabuco (McGregor, 1984), h- Bermejo river (Pérez Leyton, 1990, 1991), i- Santa Victoria borehole (Barreda, 1986), j- Cochabamba region (Blieck *et al.*, 1996), k- Galarza borehole (Ottone, 1996), l- Santa Victoria range (Grahn and Gutierrez, 2001), g- Tarabuco, h- Bermejo river, m- Balapuca, n- Sella, o- La Yesera, p- Pilaya river, q- Angosto de Huacareta, r- Sobo Sobo, s- Taputá (Grahn, 2002), m- Balapuca (di Pasquo, 2007 a, b).



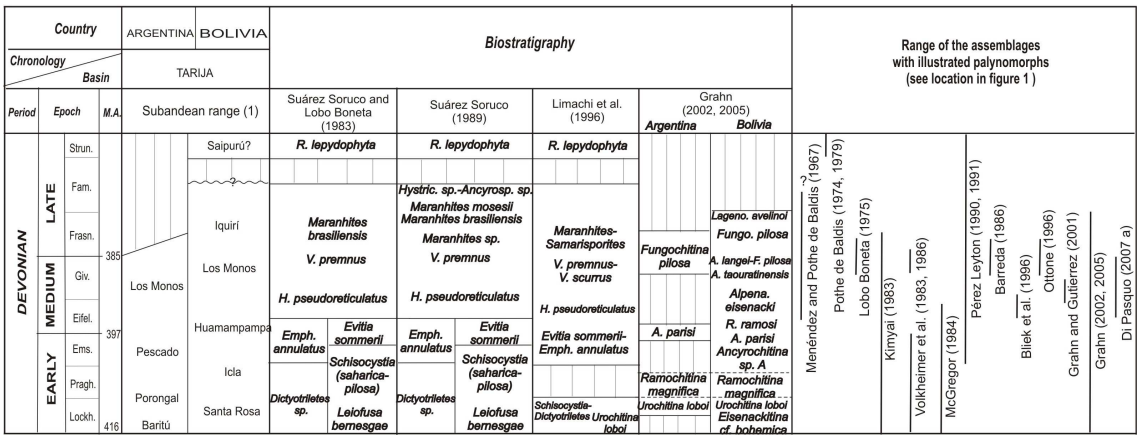


Figure 2. Generalized stratigraphic column of the Devonian Tarija Basin from northern Argentina and south to center of Bolivia (1) taken from di Pasquo (2007 a). Boundaries between stratigraphic units are not depict due to the differences in age recorded at different places (see Grahn, 2002).

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