

# Late Triassic climate in southernmost Parana Basin (Brazil): evidence from dendrochronological data

Etiene Fabbrin Pires<sup>a</sup>, Margot Guerra Sommer<sup>b,\*</sup>, Claiton Marlon dos Santos Scherer<sup>c</sup>

<sup>a</sup>CAPES/PPG-GEO, Departamento de Paleontologia e Estratigrafia, Instituto de Geociências, Universidade Federal do Rio Grande do Sul, Porto Alegre 91501-970, Brazil

<sup>b</sup>CNPq, Departamento de Paleontologia e Estratigrafia, Instituto de Geociências, Universidade Federal do Rio Grande do Sul, Porto Alegre 91501-970, Brazil

<sup>c</sup>Departamento de Paleontologia e Estratigrafia, Instituto de Geociências, Universidade Federal do Rio Grande do Sul, Porto Alegre 91501-970, Brazil

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## Abstract

Dendrochronological methods were used to study a fossil wood assemblage identified as *Sommerxylon spiralosus* Pires et Guerra-Sommer from outcropping sandstone fluvial sequences (Late Triassic of southernmost Parana Basin, Brazil). The climate signal from fossil woods, supported by sedimentary evidence, indicates a seasonal climate. Analysis of preserved growth rings has yielded information about the periodicity of growth related to seasonal cycles. The growth phase in each cycle developed at a slow rate, and the growing period was relatively uniform; in contrast, the periodic phases of growth restriction were not very extensive. These seasonal cycles were interrupted by occasional droughts during the growth season, reflected by the presence of false growth rings. These data match recent global climate patterns from the Late Triassic.

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## 1. Introduction

Fossil wood is an important component of Triassic floras from southern Parana Basin (Brazil) and, in some stratigraphic sequences, is the only plant material preserved. In Mesozoic sedimentary sequences of Rio Grande do Sul, fossil woods occur as silicified fragments that usually are found as rolled pieces on sedimentary outcrops, though they seldom occur within the sedimentary deposits. The petrified woods found in several paleontological sites have been ascribed to distinct ages and correlated with different stratigraphic units (Rosário do Sul Formation, Triassic, Gamermann, 1973; Caturrita Member of Botucatu Formation, Jurassic, Bortoluzzi, 1974; Caturrita Formation, Upper Triassic, Andreis et al., 1980; Mata Sandstone, Rhaetian interval, Faccini, 1989). The fossil record

comprises mainly conifer-related gymnosperms and may represent a mesophytic flora that originated when climate change took place during the Meso-Neotriassic transition. This flora is supposed to correspond to a younger association than the *Dicroidium* flora, according to leaf impressions recovered from Asselian-Ladinian sedimentary sequences (Guerra-Sommer et al., 1985) of the Santa Maria Formation (*sensu* Bortoluzzi, 1974).

The anatomical description of silicified gymnosperm woods from the Linha São Luiz outcrop, Faxinal do Soturno, Rio Grande do Sul, has enabled the identification of *Sommerxylon spiralosus* Pires et Guerra-Sommer (2004). Diagnostic parameters of the wood, such as heterocellular medulla composed of parenchymatic, secretory, and sclerenchymatic cells; primary xylem endarch; secondary xylem with dominant uniseriate pits; spiral thickenings in the radial walls of tracheids; an absence of resiniferous channels; and axial parenchyma indicate its relationship with the family Taxaceae and its first recognition in the Triassic of southern Pangea.

\* Corresponding author. Tel.: +55 51 33467412; fax: +55 51 3316 6340.

E-mail address: margot.sommer@ufrgs.br (M. Guerra Sommer).

This evidence supports the hypothesis of Kräusel and Jain (1963) that the Mesozoic Taxaceae were not confined to the Northern Hemisphere.

Ferigolo and Ribeiro (2000, 2001) refer to different fossils in the Linha São Luiz outcrop, represented by vertebrates (fish scales, procolophonides, dinosaurs, mammals, cinodonts), invertebrates (conchostraceans, insects), ichnofossils, fossil woods, shoots, and reproductive structures of gymnosperms. Bolzon et al. (2002) identify the impressions of leaves as *Brachyphyllum* Brogniart and the silicified woods as *Araucarioxylon* Kraus. However, Dutra and Crisafulli (2002) characterize two different patterns of leaves identified as type *Cyparissidium* and type *Pagio-phyllum*, referring to *Kaokoxylozales* (Sahni) Maheshwari for the silicified wood. Bonaparte et al. (2003) describe two new derived cinodonts from this outcrop: *Brasilodon quadrangularis* Bonaparte et al. and *Brasilitherium riograndensis* Bonaparte et al.

Schultz et al. (1994, 2000), Schultz (2001), and Cisneros and Schultz (2003) suggest a Late Ischigualastian–Early Coloradian age (approximately equivalent to Late Carnian–Early Norian of the marine European biochronology) for the fossiliferous bed of Faxinal do Soturno. The outcropping sedimentary sequence is included in either the base of the Caturrita Formation (Rubert, 2003 *sensu* Andreis et al., 1980) or the Carnian–Eonorian sequence (Pires, 2003 *sensu* Scherer et al., 2000).

On the basis of lithostratigraphic studies, Rubert (2003) claims the Ictidosauria assemblage zone (base of Norian) refers to a depositional environment related to floodplain facies in a fluvial system with channels and ephemeral shallow lakes.

In the fossil woods collected at the Linha São Luiz outcrop, the growth rings are distinct with a gradual transition from early to latewood. The study of growth rings in fossil woods allows, in certain conditions, the recognition of climatic tendencies that can be used to infer the environmental conditions during the lifetime of the plant (Creber and Francis, 1999; Parrish, 1999). This dendrochronological analysis provides important contributions for different floristic paleoprovinces (Arnold, 1947; Beck, 1953; Matten and Banks, 1967; Chaloner and Creber, 1973; Fritts, 1976; Francis, 1984; Chapman, 1994; Yao et al., 1994; Falcon-Lang, 1999; Falcon-Lang, 2000).

Bolzon's (1993) preliminary study indicates the presence of false growth rings in some gymnosperm woods from southern Parana Basin in the Mesozoic (Mata sandstone *sensu* Faccini, 1989). The generation of false growth rings was attributed to abrupt changes in the water supply, not necessarily a hot climate that was seasonally humid, annual, or cyclic (Larson, 1969).

This article aims to present new information about the Late Triassic climate in the southern Paraná Basin on the basis of a dendrochronological analysis of the fossil wood assemblage of the Linha São Luiz outcrop.

## 2. Material

The fragments of wood on which the present study is based (11 specimens) were collected during different missions from the same stratigraphic horizon in the Linha São Luiz outcrop, Faxinal do Soturno, Rio Grande do Sul, Brazil (UTM: 22J0262516E/66277528N) (Fig. 1), included either in sedimentary sequences or as rolled fragments in a transect of approximately 30 m. Preservation is usually good, and anatomical details are well preserved; specimens are mostly silicified. The fossil specimens range in size from 2 to 8.5 cm in diameter, and all include primary structures (pith and primary xylem), in addition to secondary xylem, phloem, and cortex. The circular cross-section of the growth rings indicates that they may represent remains of trunks, according to the criteria of Schweingruber (1996). Dense impregnation by iron oxide is a common feature. The type material is deposited in the Paleobotanical Sector, Departamento de Estratigrafia e Paleontologia, Instituto de Geociências, Universidade Federal do Rio Grande do Sul, Porto Alegre, Rio Grande do Sul, Brazil. Observations were made on polished surfaces combined with a graduate scale with incident light; anatomic details were observed from petrographic slides mounted in Canada balsam in transmitted light.

## 3. Facies analysis of outcrop

Using the vertical stratigraphic column (Fig. 2), it was possible to identify two facies associations: (1) massive sandstone and (2) mudstone and sandstone sheets.

### 3.1. Massive sandstone

#### 3.1.1. Description

This facies association is composed of moderately sorted, reddish, medium- to coarse-grained sandstone. The sandstone is massive and displays abundant intraformational mudstone clasts. It forms 5 m thick and more than 30 m wide packages (outcrop maximum size). Tetrapod fossils, related to cinodonts, sphenodonts, procolophonides, and dinosaurs (Ferigolo and Ribeiro, 2000; Bonaparte et al., 2003) and found either articulate or disarticulate, are common.

#### 3.1.2. Interpretation

The massive sandstones may be produced by postdepositional modification related to dewatering and bioturbation or sediment-rich gravity flow (Miall, 1996). The lack of evidence of faint residual sedimentary structures and the occurrence of different vertebrate taphonomic classes suggests fast deposition in sediment-rich gravity flows. Fonseca (1999) interprets this facies association as channel deposits generated by bank collapse.

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