THE TRIASSIC TAPHOFLORA FROM PARANÁ BASIN, SOUTHERN BRAZIL: AN OVERVIEW

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ABSTRACT A Triassic *Dicroidium* Flora identified in the central region of the State of Rio Grande do Sul, Southern Brazil, represents an important biostratigraphic stage in the palaeofloristic succession of Paraná basin.
The megafloristic association composed of compressed leaves, fronds and seeds shows a predominance of the genus *Dicroidium*, with several species, and other important taxa like *Neocalamites* sp, *Cladophlebis* sp., *Tetraptilon* aff. *heteromerum, Ginkgoites antarctica, Sphenobaiera* sp, *Podozamites* sp, *Nilssonia* sp, *Pteruchus* sp and *Carpolithus* sp. Taking into account the stratigraphic distribution of different species of the genus *Dicroidium*, a biostratigraphic framework was previously established and an informal floristic interval, named "*Dicroidium odontopteroides* Flora" was proposed (Late Anisian to Late Ladinian, Middle Triassic). The general composition of the *Dicroidium* Flora in Rio Grande do Sul is similar to the "*Dicroidietum odontopteroidium*" characterized for Australasia corresponding to a forest association composed by trees, woody shrubs, ground cover and swamps growths. The presence of xilopteroid leaves indicates levels of water stressed substrate. The homogeneous composition of the assemblage, and the small size of leaves of the whole association in relation to the *Dicroidium* Flora of other Gondwana regions (e. g. Molteno Formation) seems to indicate particular drainage patterns prevailing during deposition of Santa Maria Formation.

Keywords: *Dicroidium* Flora, South Brazilian Gondwana, Anisian, Ladinian.

INTRODUCTION

The present study aims to update biostratigraphic and palaeoecological information about plant fossils present in the Triassic sequences of Paraná basin in Rio Grande do Sul state, Southern Brazil; results obtained gave an overall picture of the knowledge of the *Dicroidium* Flora, that represents an important stage in the palaeofloristic succession of Paraná basin.

Naturalists made the first references to Mesozoic plant fossils in the state of Rio Grande do Sul at the end of the last century (Avé-Lallemant 1880, Isabelle 1883). Until the fifties these fossil plants were just mentioned, together with reptiles, as biostratigraphic markers in studies that tried to establish the stratigraphy of the gondwanic series in Southern Brazil (White 1908, Moraes Rego 1930, Huene & Stahlecker 1931, Fiuza da Rocha & Scorza 1940, Gordon Jr. 1947, Beurlen *et al*. 1955, Rau 1933, Gordon Jr. & Brown 1952, Pinto 1956). From 1965 on, studies on frequency, location of stratigraphic horizons were developed (Beltrão 1965, Bortoluzzi & Barberena 1967, Bortoluzzi 1975). Bortoluzzi & Barberena (1967), for the first time, interpreted megaplant association as representatives of the so-called "*Thinnfeldia-Dicroidium* Flora", nowadays named "*Dicroidium* Flora".

After 1980 important contributions concerning *Dicroidium* Flora of Rio Grande do Sul were carried out (Bortoluzzi *et al.* 1983, 1984 and 1985, Guerra-Sommer *et al.* 1985, Mastroberti 1997, Iannuzzi & Schultz 1997, Guerra-Sommer *et al*. 1998, Guerra-Sommer *et al*. 1999). These studies have resulted in a substantial increase in the knowledge of the flora. Sequences containing *Dicroidium* flora were dated as Triassic, according to the criteria of Gamermann (1973), Bortoluzzi (1973), Andrei (1980) and Faccini (1989).

Using sequence stratigraphy, Milani *et al.* (1997) characterize six megasequences for the Paleozoic and Mesozoic intervals of the Paraná basin. According Milani *et al.* (1997) the depositional history of Paraná basin produced continental sequences controlled by tectonism and climatic changes. The late Triassic Megasequence (lTr) is represented, in the southern part of the basin, by the Santa Maria Formation (Fig 1). According to these authors, the sediments of this unit were formed in a fluvial/lacustrine environment.

Sedimentary sequences containing the best deposits of leaf impressions are located close to the city of Santa Maria mainly in outcrops named by Bortoluzzi (1974) as Passo das Tropas and Dom Antônio Reis, both linked to the same stratigraphic level, which corresponds to a conglomerate with interbedded mudstone levels. Fragmentary plant collections were registered in siltstones and mudstones from Hospital and Olaria outcrops, which correspond to the basal part of the sequence outcropping at Passo das Tropas locality.

THE SOUTHERN BRAZILIAN "*DICROIDIUM* FLORA"

Based on the above mentioned studies, the *Dicroidium* Flora in Rio Grande do Sul State is composed of following elements, according to taxonomic studies of Bortoluzzi *et al.* (1983, 1984, 1985) and Guerra-Sommer *et al.* (1985, 1999):

SPHENOPHYTA - *Neocalamites* sp.

PTERIDOPHYLLA - *Cladophlebis* sp.

Tetraptilon aff. *T. heteromerum* Frenguelli 1950

PTERIDOSPERMOPHYTA - *Thinnfeldia* sp.

Dicroidium lancifolium (Morris) Gothan 1912

Dicroidium (Johnstonia) stelzneriana (Gein.) Frenguelli 1941

Dicroidium (Xylopteris) argentinum (Kurtz) Arrondo 1972

Dicroidium lancifolium Petriella 1978

Dicroidium (Xylopteris) elongatum (Carruthers) Archangelsky 1968

Dicroidium odontopteroides (Morris) Gothan 1912

Dicroidium odontopteroides var. *odontopteroides* (Morris) Gothan 1912

Dicroidium odontopteroides var. *remotum* (Szajnocha) Retallack 1977

Dicroidium odontopteroides var. *moltenense* Retallack 1977

Dicroidium zuberi var. *zuberi* (Szajnocha) Archangelsky 1968

Dicroidium zuberi var. *papillatum* (Townrow) Retallack 1977

Dicroidium zuberi var. *brasiliensis* Petriella 1978

Dicroidium zuberi var. *feistmantelii* (Johnston) Retallack 1977

Dicroidium dubium Jacob & Jacob 1950

Dicroidium aff. narrabeenense (Dun in Walkom) Jacob & Jacob 1950

Pteruchus sp.

GINKGOPHYTA - *Ginkgoites antartica* (Saporta) Shirley 1898

Sphenobaiera sp.

CYCADOPHYTA - *Williamsonia* sp.

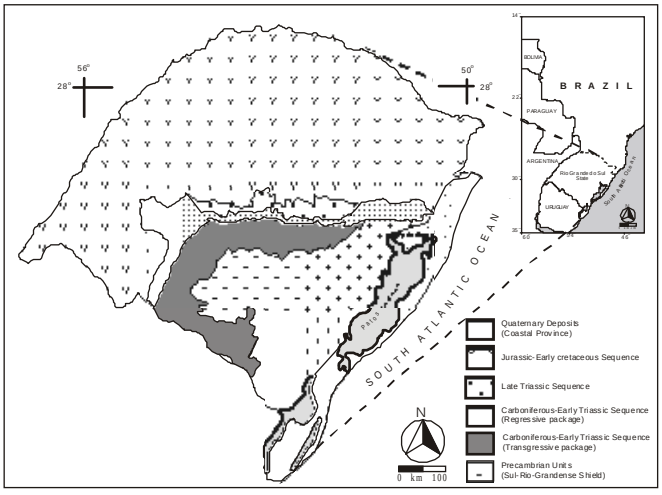

Figure 1 – Location of the Gondwana Sequence in Rio Grande do Sul, southern Brazil (modified after Scherer et al. 1999)

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CONIFEROPHYTA - *Podozamites* sp.

INCERTAE SEDIS - *Taeniopteris* sp.

Sewardia sp.

Nilssonia sp.

Carpolithus sp.

The most important taxa collected from Passo das Tropas outcrop are illustrated in figs. 2, 3 and 4, al material mentioned in this paper is kept at the Palaeobotany section, Institute of Geosciences, UFRGS.

Barberena & Bortoluzzi (1977) suggested a preliminary biostratigraphic zoning for Santa Maria Formation with two tetrapod biozones: Therapsida Cenozone and Rhyncocephalia Cenozone, with an "intermediate biozone" of *Dicroidium*. Guerra-Sommer *et al*.

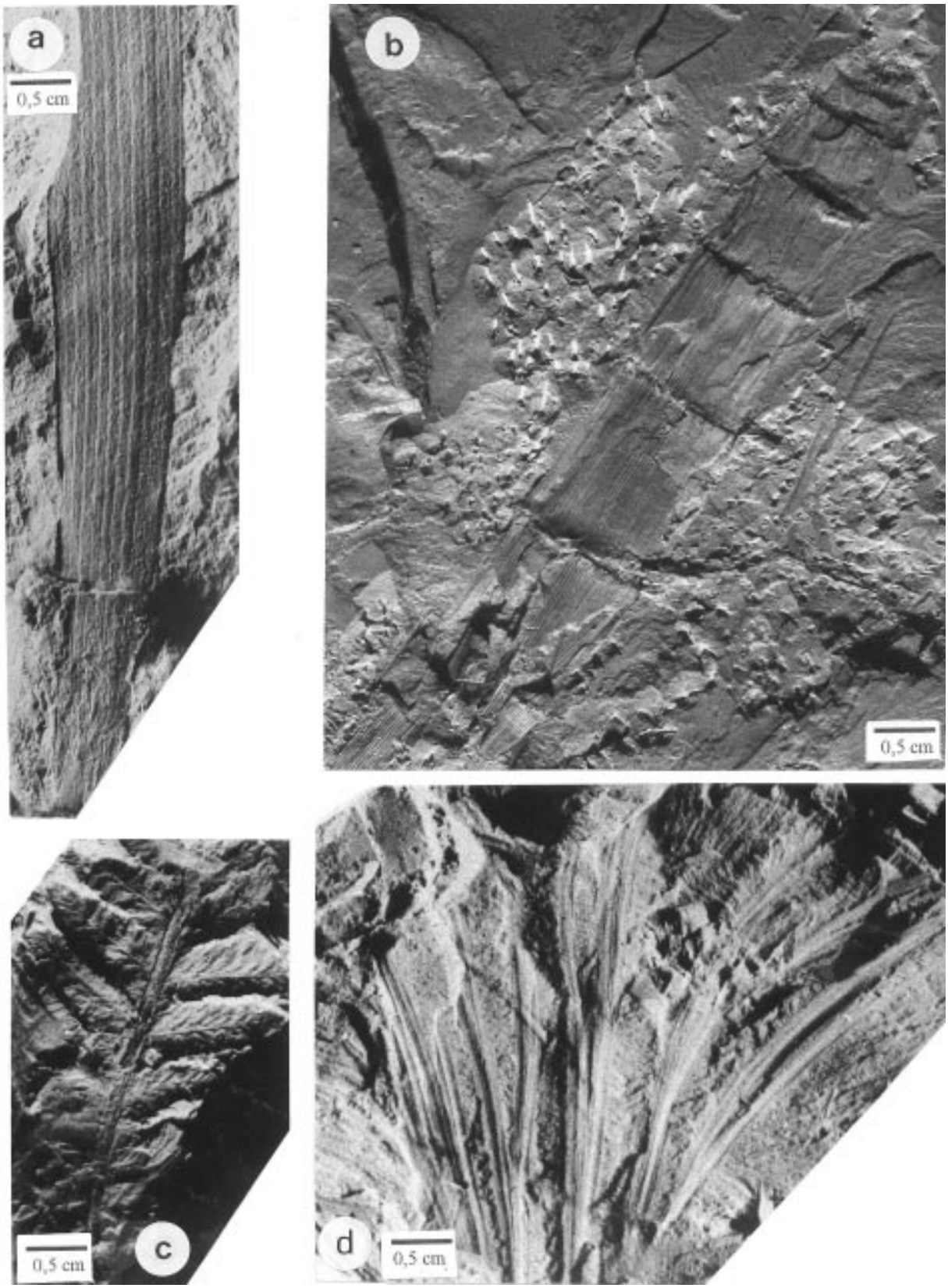

Figure 2 - a - Podozamites sp.; b - Neocalamites sp.; c - Chladophlebis sp.; d - Sphenobaiera sp.

(1985) include the *Dicroidium* Flora of Rio Grande do Sul in the *Dicroidium odontopteroides* "oppel-zone" of Retallack 1977. Barberena *et al*. (1993) kept the Therapsida and Rhyncocephalia Cenozones, but suggest abandoning the *Dicroidium* Cenozone proposed by Barberena & Bortoluzzi (1977).

Aiming the fitostratigraphic refinement of Triassic sequence in southern Brazil, the stratigraphic distribution of different species of the genus *Dicroidium* has been taken as the main reference for the study of Guerra-Sommer *et al*. (1999). A chart was built based on the maximum stratigraphic range presented by Retallack (1977) and Petriella (1983) for species of *Dicroidium* in Australasia and Argentina, respectively. The species of *Dicroidium* occurring in southern

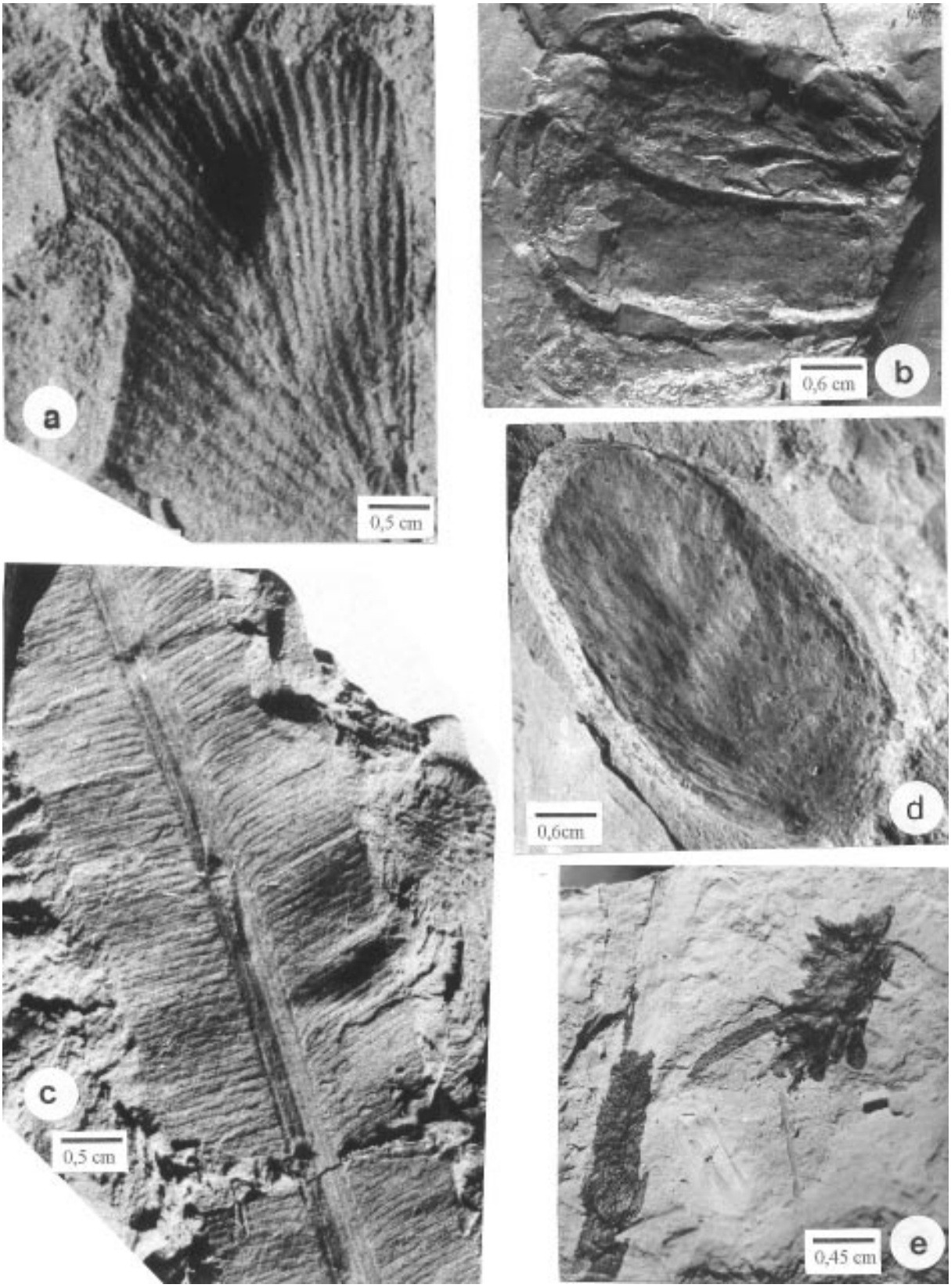

Figure 3 - a - Ginkgoites antactica; b - Williamsonia sp.; c - Taeniopteris sp.; d - Carpolithus sp.; e - Pteruchus sp.

Brazil indicated a time interval corresponding to Neo-Anisian/Neo-Ladinian (Middle Triassic). *Dicroidium odontopteroides* var. *remotum* represents the taxon of greatest biostratigraphic value in the association (Fig. 2).

Guerra-Sommer *et al*. (1999) concluded that the characteristics presented by the studied associations, such as diversity of species and abundance of specimens associated with the limited geographic and stratigraphic occurrence, were insufficient for the establishment of a formal zoning. An informal palaeofloristic interval named "*Dicroidium odontopteroides* Flora" was therefore suggested.

The general composition of *Dicroidium* Flora in Rio Grande do Sul state is similar to the "Dicroidietum odontopteroidium" Floral

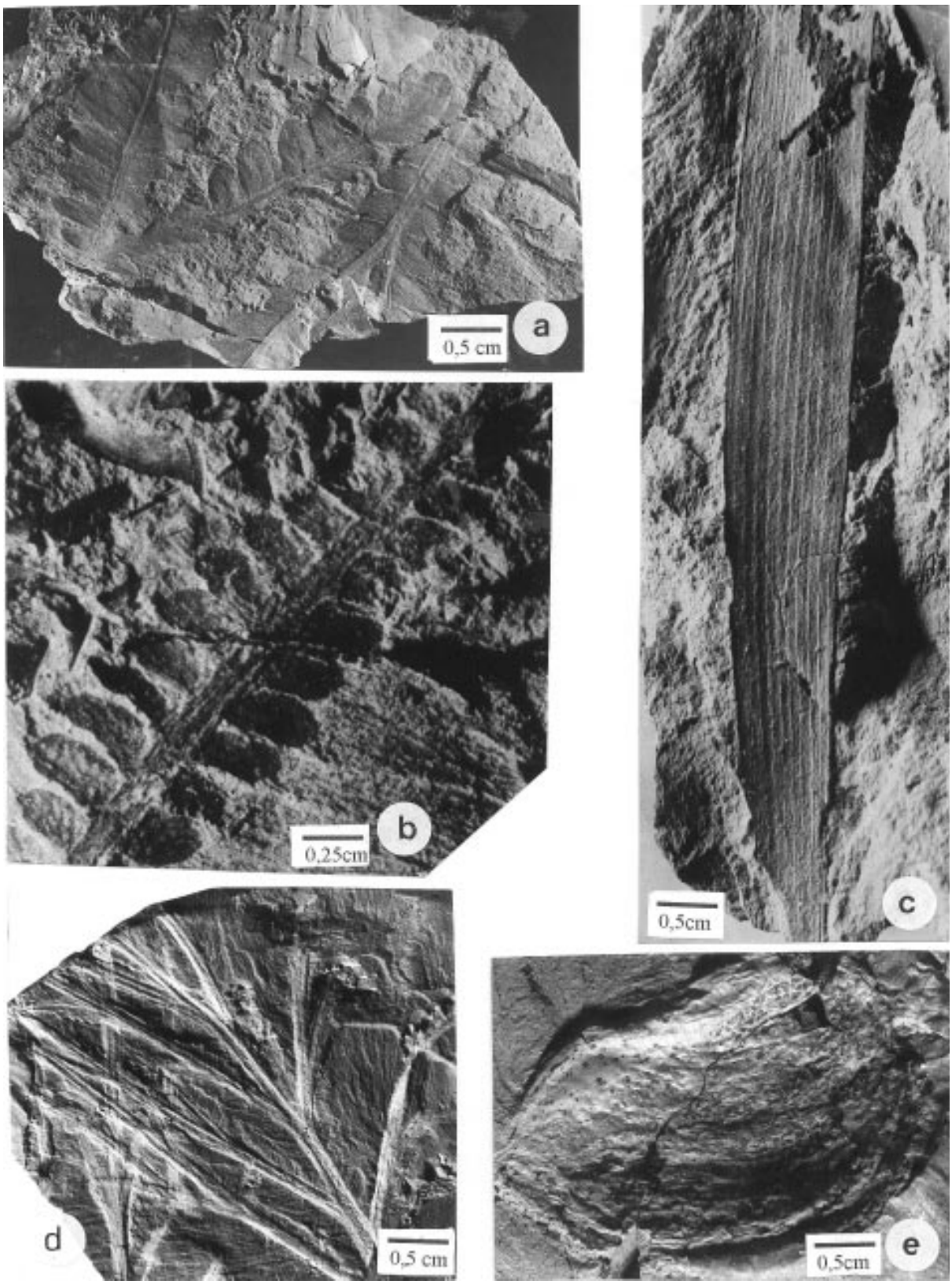

Figure 4 - a - Dicroidium odontopteroides; b - Tetraptilon aff. heteromerum; c - Podozamites sp.; d - Dicroidium (Xylopteris) elongatus; e - Carpolithus sp.

association, characterized by Retallack (1977) for Australasia. This phytoassociation was probably composed of a variety of structural elements, including trees (conifers, ginkgophytes and pteridosperms), woody shrubs (*Nilssonia*), ground cover (ferns) and swamps growths (sfenophytes). The paleoflora was developed both in meandering and braided channel deposits in fluvial and lacustrine systems.

The most diversified and abundantly preserved plant group was related to *Dicroidium*, represented by forms with an expanded leaf area, as *D. odontopteroides* for instance.

A drier paleoenvironment suggested by the presence of *Dicroidium* (*Xylopteris*) *elongatum* and *Dicroidium* (*Xylopteris*) *argentinum* forms with reduced leaf area and also supported by other associated narrow-lived species of *Sphenobaiera*, are indicatives of xerophillous paleoenviroment. These forms can be related to Retallack's "Dicroidietum odontopteroidium xilopterosum" phytoassociation, developed in a low fertility, water stressed substrate, in the flood plain.

In general, the pattern of vegetation throughout the plain was probably fairly uniform. Local variation certainly occurred in different specialized habitats, as it seems to be demonstrated by the Olaria outcrop plant assemblage (Bortoluzzi 1974), where *Podozamites* occur almost as an exclusive form.

The paleofloristic data are in agreement with the idea of Faccini (1989) and Scherer (1994) using facies analysis which indicate a strong climate control over sedimentation in the Santa Maria Formation.

It is important to point out that the whole association of "*Dicroidium* Flora" belonging to the South Brazilian sequence is homogeneous when compared with the exuberance of the Triassic Molteno assemblage, South Africa (Anderson 1974). The leaves are, on the other hand, only a half or a third the size of those of South African assemblage. This change of leaf size in leaves of the same species in correlated stratigraphic horizons could be related to water deficit or dryness of climate. Thus, the trend toward enrichment in species and the appearance of new types, and the expanded leaf size, could be related to the paleogeographic position of South Brazilian an South African Gondwana during the Triassic global greenhouse stage.

Considering the similar latitudes (near 60° S) between Paraná and Karro Basins at the Ladinian-Anisian interval (Smith *et al*. 1994) distinct drainage patterns could be responsible for the different characteristics of the paleofloras.

According Ryan 1967 (*in* Anderson 1974) the physiographic conditions that prevailed during Molteno times indicates that the Molteno Plain was a depressed region, surrounded by highland areas, with a poor drainage exit. Consequently, swamp conditions were established, originating a rich *Dicroidium* Flora, with large size leaves. In Paraná basin, on the other hand, at this time better drainage patterns allow drier conditions and the development of a floral association adapted to seasonal paleoenvironment.

Acknowledgements To two referees of RBG for the critical review of the manuscript.

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Contribution IGC-004
Received January 10, 2000
Accepted for publication May 23, 2000