
THE BRAZILIAN GONDWANIC FLORAL SUCCESSION

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This paper has the objective to present an actualized scheme of the distribution of fossil plant assemblages in the outcropping sediments of the Paraná Basin (Brazil). Based

on this scheme some general aspects, including the problem of the Carboniferous-Permian boundary, are briefly discussed.

A review of such distribution was pre-

sented by RIGBY (1970), suggesting the possibility to recognize two floras, calling the flora of Tubarão Group the “*Glossopteris-Gangamopteris* Flora”, and the flora of Passa Dois Group the “*Lycopodiopsis* Flora”. RÖSLER (1973) distinguished four groups of fossil plant assemblages (= Taphofloras) named by letters *A* (older) to *D* (younger). A younger taphoflora (*E*) was discovered thereafter in the Uppermost Permian (RÖSLER, 1975a, 1975b & in press).

The present paper is a synopsis and brings this subdivision up to date. It is mainly based on the result of an extensive systematic field work during which tens of new fossil plant localities were discovered, some of them very important to this study, like S. J. Triunfo (1 RB/PR), Fluviópolis (86 EN/PR) and Dorizon (79 RR/PR) (Fig. 1).

All samples collected during the field work programme referred here are in the Palaeobotanical Collection of the Department of Palaeontology and Stratigraphy, Institute of Geoscience, University of São Paulo (Brazil).

Six fossil plant assemblages (taphofloras) were recognized (Fig. 2):

Taphoflora A — Characterized by: *Paracalamites*, *Paranocloodus*, *Lycopodiopsis pedroanus* and *Samaropsis* as common elements. Presence of *Botrychiopsis*, *Noeggerathiopsis*, *Buriadia*, etc. Absence, at least apparently, of *Gangamopteris* and *Glossopteris*. Occurrence: Itararé Subgroup, Monte Mor Locality (4 IT/SP), São Paulo State. It is the oldest taphoflora of the studied sequence. Probable age: Stephanian.

Taphoflora B — Characteristics: *Asterotheca*, *Pecopteris* spp. and *Annularia* are abundant. Relatively common elements are: *Paranocloodus*, *Lycopodiopsis pedroanus*, *Paracalamites*, *Gangamopteris*, *Glossopteris*, *Sphenophyllum*, etc. Occurrence: Basal to middle part of the Rio Bonito Formation, mainly at localities of Northeast and South of Parana State. Typical locality: São João do Triunfo (1 RB/PR). Age: Lower Permian.

Taphoflora C — Characteristics: *Glossopteris* and *Gangamopteris* are abundant. Relatively

common elements are: *Arberia*, *Noeggerathiopsis*, *Rhodiopteridium*, and many others according to the localities. *Lycopodiopsis* is not common and ferns are rare. *Annularia* has not been recorded. Occurrence: Mainly in the upper, but some in the middle part of Rio Bonito Formation, in the North and South of Santa Catarina State. Typical locality: Criciuma, S. Catarina (21 RB/SC). Probable age: Artinskian to Kungurian.

Taphoflora D — Characteristics: Presence of *Lycopodiopsis derbyi* as one of the most common elements. Some localities have yielded *Krauselcladus* (Yoshida, 1970), Ginkgo phyte leaves, and Charophyte remains. Absence of several characteristic forms of the taphofloras A, B and C. Taphoflora D could be called a “taphofloristic complex”. Occurrence: Irati Formation with an informal *Polysolemoxylon* zone) and mainly Estrada Nova Formation, from São Paulo to Rio Grande do Sul. Typical localities: Artemis (3 EN/SP), Laras (7 EN/SP) and Fluviópolis (86 EN/PR). Age: Upper Permian.

Taphoflora E — Characteristics: This taphoflora contains the last (youngest) occurrences of Glossopterids. They are represented by some few species of *Glossopteris*, generally small and particularly narrow leaves. *Sphenophyllum* are of the *Sph. speciosum* type. Other elements are considerably less common, but it is important to quote the presence of *?Dizeugetheca* sp. Occurrence: Rio do Rasto Formation in Paraná and Santa Catarina. Typical locality: Dorizon, Parana (79 RR/PR). Age: Upper Permian to? Lower Triassic.

Taphoflora F — Characteristics: Several of *Dicroidium* and other elements of Triassic age. Absence of the characteristic elements of the preceding taphofloras. Occurrence: Santa Maria “facies” (Rosario do Sul Formation, Rio Grande do Sul (75 SM/RS, etc.). Age: Middle Triassic.

Some localities like Cerquilho Velho (38 IT/SP) and Acampamento Velho (33 TU/RS) seem to represent the first occurrences of Glossopterids. Until further studies I am considering them as intermediary (or Transi-

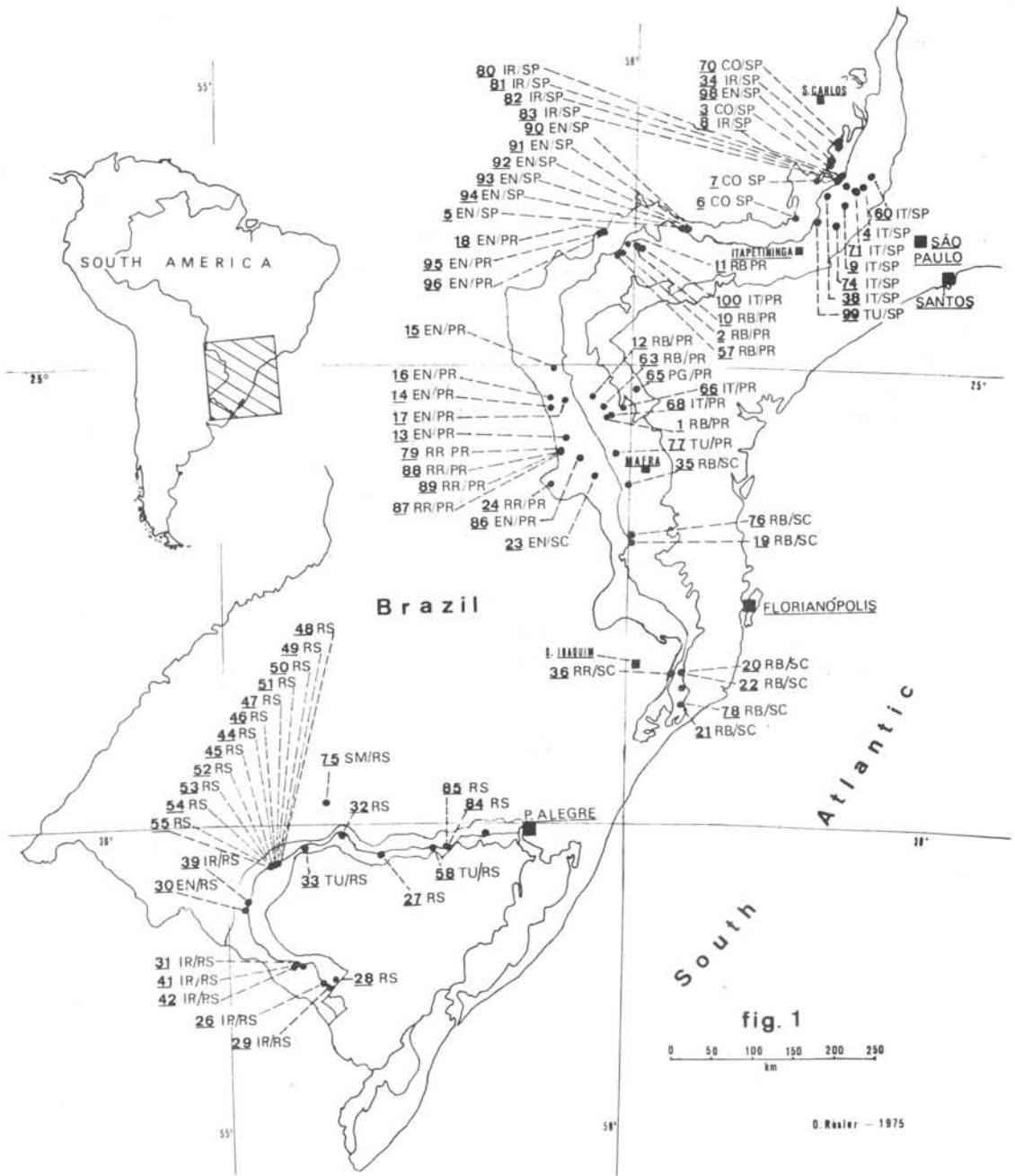


FIG. 1

Eastern area of outcropping sediments of the Paraná Basin, showing the relative situation of the localities referred in the text and fig. 2.

Major stratigraphic and geographic situation of each locality is indicated by the letters:

Lithostratigraphic units:

- CO – Corumbataí Formation
- EN – Estrada Nova Formation
- GU – Guatá Subgroup
- IR – Irati Formation
- IT – Itararé Subgroup
- PA – Palermo Formation
- PD – Passa Dois Group
- RB – Rio Bonito Formation

- RO – Rosário do Sul Formation
- RR – Rio do Rasto Formation
- SM – Santa Maria Formation
- TU – Tubarão Group

Geographic names:

- PR – State of Paraná
- RS – State of Rio Grande do Sul
- SC – State of Santa Catarina
- SP – State of São Paulo

tional) between taphofloras A and B. Those localities contain mainly "gangamopteroids" leaves. Thus, the oldest rest of Glossopterids found during this study are those of the uppermost part of the Itararé Subgroup below the last recorded (youngest) diamictites.

The first (oldest) abundant and clearly distinguished *Glossopteris* species in the lowermost part of the Rio Bonito Formation in several localities. The predominance of *Glossopteridales* in the assemblages is observed in the middle and upper part of the Rio Bonito Formation, mainly in Santa Catarina and Paraná States. Their younger occurrence is in the Rio do Rasto Formation. So, the lower limit of

Glossopteris in this area coincides with the probable transition to post glacial conditions and its upper limit coincides with increasingly arid conditions. The actual record suggests that *Gangamopteris* appeared before *Glossopteris*.

There are several causes that could be pointed as responsible for the differences and similarities among these fossil plant assemblages. Obviously some of the differences and similarities are clearly caused by local conditions of deposition. This is mainly true for Taphoflora D, where assemblage composition varies considerably from one

TAPHOFLORES	A 'trans'		B						C				D				E	F												
LITHOSTRATIGRAPHIC UNITS	Tubarão Group														Passa Dois Group		S.Bto.													
LOCALITES	Itararé		Guatá Sp.				Rio Bonito Fm.				Estrada Nova Formation				R. Rasto Fm.	SMFM														
REPRESENTATIVE TAXA	4 IT/SP	38 IT/SP	33 TU/RS	57 RB/PR	10 RB/PR	11 RB/PR	12 RB/PR	2 RB/PR	1 RB/PR	25 GU/RS	28 GU/RS	21 RB/SC	78 RB/SC	20 RB/SC	35 RB/SC	3 EN/SP	7 EN/SP	86 EN/SP	13 EN/SP	14 EN/SP	15 EN/PR	17 EN/PR	18 EN/PR	30 EN/RS	24 RR/SC	36 RR/SC	79 RR/PR	87 RR/PR	75a SM/RS	75b SM/RS
" <i>Rhacopteris</i> " (in Millan, 1972)	☆																													
<i>Botrychiopsis</i> Kurtz	○			○								○																		
<i>Paranocladus</i> Florin	●	☆		●	○	○	☆	●																						
<i>Buriadia</i> Seward and Sahni	○	☆		○			○	☆				○	☆	○																
<i>Lycopodiopsis pedroanus</i> (Car-ruthers) Edwards	○	☆		○	○	○	○	●		○	○	○	○	○																
<i>Noeggerathiopsis</i> Feistmantel	○	☆	○				○			○	○	○	○	○																
<i>Phyllothea</i> Brongniart		○	○				○	○	○	○	○	○	○	○		☆														
? <i>Gangamopteris</i> McCoy																☆														
? <i>Glossopteris</i> Brongniart		☆	○																											
<i>Sphenophyllum brasiliensis</i> Rösler				○				○																						
<i>Gangamopteris obovata</i> (Car-ruthers) White				○			○	☆	☆	○	○	○	○	☆						☆				☆						
<i>Asterotheca cambuhyensis</i> (Read) Rösler (m/s)				○			☆	○	●																					
<i>A. derbyi</i> Rösler (m/s)								○	●																					
<i>Annularia</i> Stenberg				○				○	●																					
<i>Gangamopteris burladica</i> var. <i>acrodeltoidis</i> Dolianiti												○																		
<i>Glossopteris augustifolia</i> Brongniart												○							☆	○	○					☆		○		
<i>G. augustifolia</i> var. <i>taeniopteroides</i> viz. <i>G. sewardii</i> Plumstead												○																		
<i>Gangamopteris cylopteroides</i> Feistmantel												○																		
<i>G. mosesi</i> Dolianiti												○																		
<i>Arberia</i> White												○	○	○	☆															
<i>Rhodiopteridium</i> Zimmermann												○	○																	
<i>Lycopodiopsis derbyi</i> Renault																●	●	○				○	○							
<i>L. dolianiti</i> Krausel																						○	○							
? <i>Asterotheca</i> spp. (including? <i>A. ferruglioi</i> , in Rigby, 1968)																														
<i>Pecopteris</i> spp. (including <i>P. paranaensis</i> , in Rigby, 1968)																														
<i>Thalites</i> (in Rigby 1968, 1970)																														
<i>Glossopteris</i> sp.																									○	○	●			
<i>Sphenophyllum</i> cf. <i>speciosum</i>																									○	☆	○	○		
<i>Dicroidium</i> Flora spp.																													●	●

○ : The taxon occurs at the locality. ● : Particularly abundant. ☆ : Occurrence of a cf. or aff. taxon.

FIG. 2

Distribution of some representative taxa in the main localities arranged in stratigraphic order. Locality notation as in fig. 1.

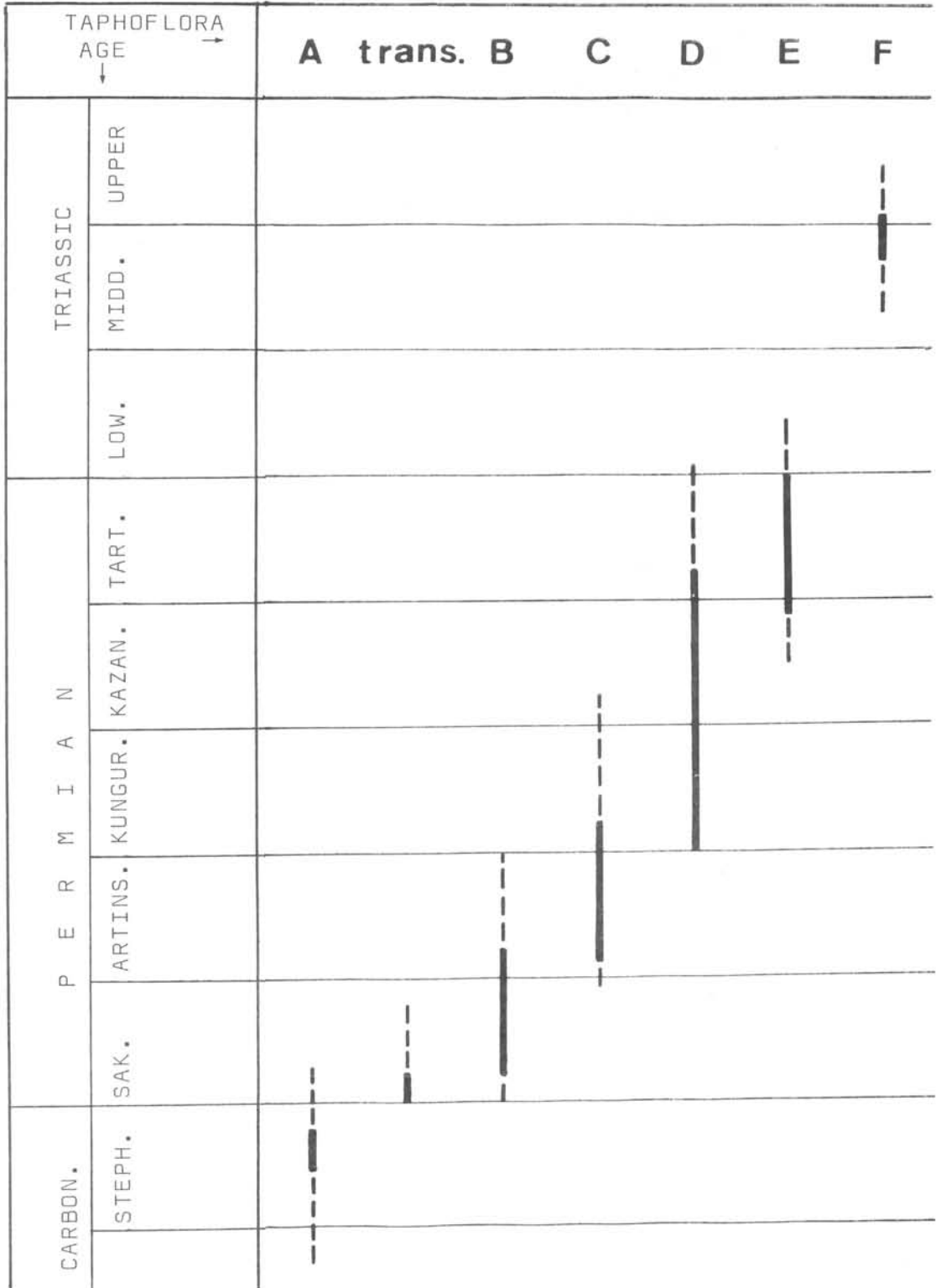


FIG - 3

Probable age ranges (solid lines) and possible age range (dashed lines) of the taphofloras dealt with in this paper.

outcrop to another, though there are similarities in the composition among some of them with similar lithology. That is why taphoflora D has been referred as a "taphoflorist complex" which stratigraphic position is above Taphofloras A, B and C, and below E.

Taphofloras A, B and C are mainly associated with the coal bearing strata. Some of their characteristics are due to "taphogenic causes" (KRASSILOV, 1969), but at least some others almost certainly reflect part of the original floral compositions. Taking the latter aspects into consideration, Taphoflora A would represent a Pre-*Glossopteris* Flora; Taphoflora B would represent a *Glossopteris* Flora mixed with "northern" forms, and Taphoflora C would represent a "pure" *Glossopteris* flora. The same aspects also suggest some significant "subprovincial" differentiations across the studied region, but it is still very difficult to propose any phyto-geographic unit.

Correlation of these taphofloras, based on their stratigraphic situation, on palynological studies and on the fossil plants themselves shows that Taphoflora C, is, at least in part, younger than B, and B, is younger than A (Fig.3).

There is at present insufficient basis for a definitive assignment of ages to the succession dealt with here, in terms of the internationally recognized geological time table. The ages here referred (see Fig. 3) are the best approximation possible on the present evidence. The Carboniferous-Permian boundary is localized between Taphoflora A and the "transitional" one, i. e. about the middle part of the Itarare Subgroup.

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ENSAIO SOBRE A UTILIZAÇÃO DE CARACTERES BIOMÉTRICOS DAS GLOSSOPTERIDÓFITAS EM ESTRATIGRAFIA

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ABSTRACT

An evolutionary sequence of forms is proposed for the glossopteridophytes based on the morphographic characters of their leaves. Considering the average biometric properties of some of these characters, several "evolutionary indices" are proposed, that may be useful in eogondwanic biostratigraphy.

INTRODUÇÃO

Ao elaborar o Plano do *Traité de Paléobotanique*, BOUREAU (1967) introduziu na Sistemática Vegetal um novo taxon: Glossopteridophyta. O grande grupo de plantas eogondwânicas é caracterizado por vários tipos de folhas designadas pelos gêneros-formas *Glossopteris*, *Gangamopteris*, *Palaeovittaria*, *Rubidgea*; por numerosas frutificações a elas relacionadas, tais como: *Ottokaria*, *Scutum*, *Lanceolatus*, *Hirsutum*, *Senotheca*, etc., além de uma raiz ou rizoma (conforme SCHOPF, 1965 e GOULD, 1975) conhecida como *Vertebraria*.

Consideremos, por ora, apenas os gêneros-formas para folhas.

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