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## The Holocene paleoenvironment in the Serra Velha region, RS, Brazil through a study of plant succession

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**Abstract** - Palynological studies in the marsh forest of Serra Velha (29°36'S – 51°38'W), Rio Grande do Sul, Brazil, detected a plant succession through hydrosere from a water body already somewhat filled up by herbaceous vegetation at 9800 ± 90 yr BP. The climatic amelioration at the beginning of the Holocene accentuated the filling up process. Later, between 7800 - 7280 ± 60 yr BP, a short phase of significant influence of the forest over the marsh occurred. A new significant expansion of the forest, beginning at about 6000 yr BP took place. This gave rise to the present forest which is represented by many species of the Atlantic rain forest. Compared to the already existing palynological data about the Coastal Plain, it becomes evident that the present Serra Velha forest is older, which seems to indicate the importance of the foothill forests of Serra Geral in forming the present coastal vegetation in Rio Grande do Sul.

**Keywords** - Palynology, Paleoenvironment, Southern Brazil, Holocene.

### INTRODUCTION

Some palynological papers have already presented studies of the plant succession and the behaviour of the Atlantic rain forest in the Coastal Plain of Rio Grande do Sul during the Holocene (Cordeiro & Lorscheitter, 1994; Lorscheitter, 1987; Lorscheitter & Dillenburg, 1998; Neves, 1998; Neves & Lorscheitter,

1995; Werneck & Lorscheitter, 2001). However, there are no palynological data about the Holocene of Serra Geral foothills, which also have elements of the Atlantic rain forest (Rizzini, 1997) and seem to have been important migratory routes of the forest vegetation, according to floristic data of Rambo (1950; 1951).

Then, the objective of this study is to obtain information about the plant succession which gave rise to the present forest vegetation in the Serra Geral foothill region, the influence of the latest millennia climate on the vegetation changes and the corresponding chronologies. Therefore, a sedimentary core was collected in a Serra Velha marsh forest, 50 m alt, at 29°36'S – 51°38'W, where samples for palynological analysis and for <sup>14</sup>C dates were obtained (Fig. 1).

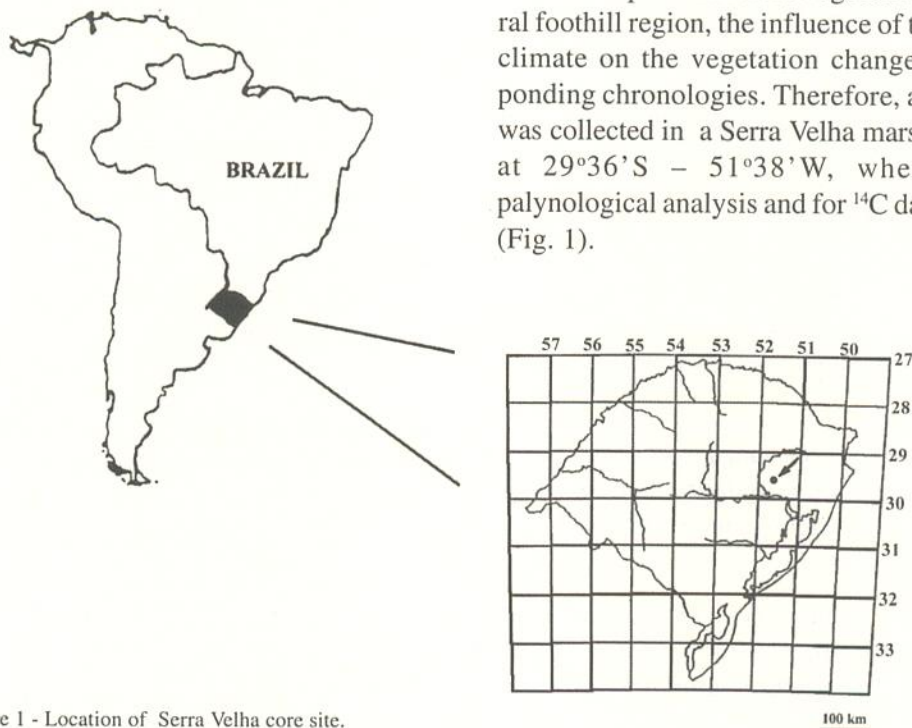


Figure 1 - Location of Serra Velha core site.

## MATERIAL AND METHODS

The chosen region is located close to the first steps of the cliffs of Serra Geral, with valleys and various sandstone elevations. In the lower part of the valleys, marsh soils and various streams are found. The climate is subtropical and the vegetation is highly influenced by the Atlantic rain forest.

Serra Velha is located close to the first steps of the Serra Geral cliffs, in the Brochier do Maratá Valley, where marsh forests with many species of the Atlantic rain forest are developing.

The core of 512 cm depth was collected in the central part of a forest with a Hiller sampler, from which samples were taken and processed for palynological analysis and  $^{14}\text{C}$  dates. The chemical processing was standard, described by Faegri & Iversen (1989), using HCl, HF, KOH and acetolysis, filtering in a 250  $\mu\text{m}$  net. The slides were mounted in glycerol-jelly (Salgado-Labouriau, 1973). Whenever possible, a significative minimum number of 500 pollen and spores grains per sample were counted, leaving out other palynomorphs. Saturation curves monitored the significative minimum number of the counted grains. From these counting results, the palynological diagrams, the basis for paleoenvironment interpretations, were drawn up. Two conventional sediment  $^{14}\text{C}$  dates, made at Beta Analytic Inc., Florida, U.S.A., enabled the chronological linking of palynological results. These dates were also used for the chronological estimate of some events, supposing a uniform sedimentation rate for each lithology (Fig. 2).

## RESULTS

1. Gathering of pollen and spores according to their origin environment for paleoenvironment analysis the palynomorphs were separated as it follows:

### – Herbaceous marsh

(Alismataceae, *Anthoceros*, *Blechnum* type, Cyperaceae, Eriocaulaceae, *Isoetes*, *Myriophyllum*, *Osmunda*, *Phaeoceros*, *Selaginella*, *Sphagnum* and *Typha*),

### – Forest

*Acacia*, *Alchornea triplinervia* (Spr.) M. Arg., Anacardiaceae, *Cecropia*, *Celtis*, *Erythrina*, *Ilex*, Meliaceae, *Microgramma*, *Phrygilanthus*, *Mimosa*, *Myrsine*, Myrtaceae, *Roupala*, *Trema*, indeterminate tricolporates and Urticales.

### – Dry soil

*Alternanthera*, *Amaranthus*-Chenopodiaceae type, *Baccharis* type, *Cuphea*, *Gnaphalium*, *Gomphrena*, *Plantago* and *Vernonia*.

### – Field

Poaceae

## 2. Zonation of the palynological diagrams (Fig. 2)

### Zone I (depth 512 to 350 cm)

The sediments are composed of homogeneous dark sandy clay. The interval is characterized by the predominance of herbaceous marsh indicators with significant frequency of aquatic components, such as *Isoetes*. The pollen of pioneer arboreal species is less frequent and increases towards the top of the zone, where Poaceae and dry soil species decrease.

### Zone II (depth 350 to 254 cm)

The homogeneous dark sandy clay sediments are replaced in the upper part of this zone by sediments rich in organic material. There is a significant increase of arboreal pollen frequency and a considerable reduction of Poaceae (the lowest frequency of the core) and dry soil indicators. Then, there is a great reduction of arboreal elements and herbaceous marsh indicators, and an increase of dry soil components. Finally, at the top of the zone arboreal and herbaceous marsh indicators become more frequent.

### Zone III (depth from 254 cm to the top)

This interval is dominated by rich organic material sediments. The arboreal indicators frequency keeps on increasing with slight oscillations and significantly augments at the highest level of the core, opposite to the herbaceous marsh indicators. At a depth of 1m, there is a significant frequency of Poaceae, which rapidly decreases, to immediately increase a little again, together with dry soil elements, at the top of the core, while forest indicators decrease.

## RESULT ANALYSIS

The base of zone I is dated at  $9800 \pm 90$  yr BP (Beta 154709), indicating the beginning of the Holocene. Aquatic vegetation and herbaceous marshes are abundant, showing an already partially filled up water body. This probably can be explained due to the Holocene climate amelioration, which increased colonization of plants. The pioneer arboreal plants

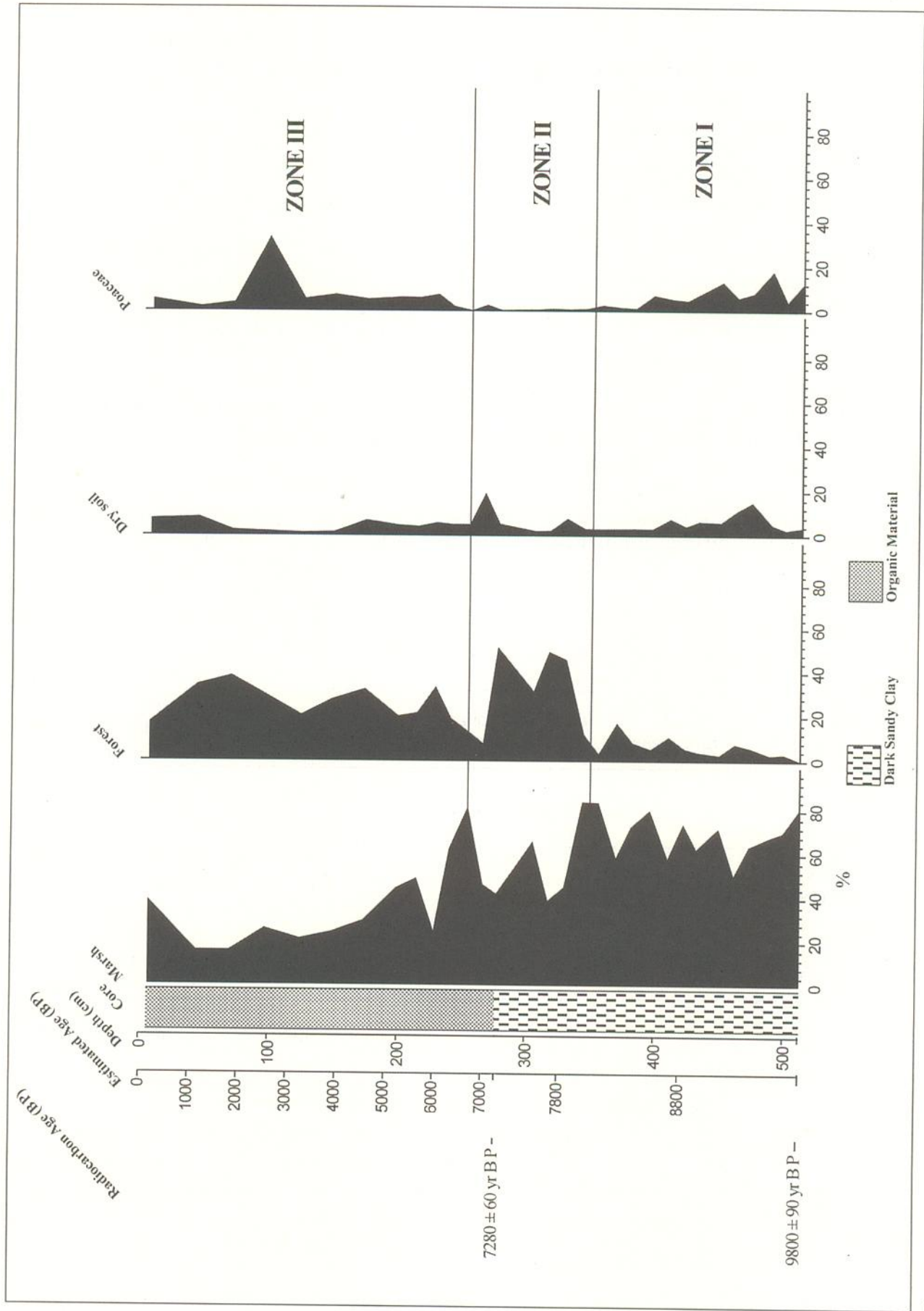


Figure 2 - Palynological percentage diagram.

(such as *Alchornea triplinervia*, *Celtis*, *Myrsine* and *Trema*) increase, in a much less expressive way, showing three small advances and regressions, opposite to the advances and regressions of the herbaceous marsh components. These oscillations related to the arboreal and herbaceous vegetation seem to indicate slight climate changes within a general tendency towards the gradual development of the forest. These data are confirmed by dry soil plants and Poaceae, components of adjacent fields which, though scarce, decrease significantly. This set of data seems to indicate that the climate gradually became milder and more humid at the beginning of the Holocene, conforming, therefore, with the palynological results obtained for the east plateau of Rio Grande do Sul (Roth & Lorscheitter, 1993).

The upper part of zone II was dated at  $7280 \pm 60$  yr BP (Beta 151165). In this zone there are evidences of a significative expansion of the marsh forest over the swamp, estimated at about 7800 - 7280  $\pm 60$  yr BP, with two distinct oscillations. The accentuated sea level increase, detected by Werneck & Lorscheitter (2001) and Medeanic *et al.* (2001) for the Coastal Plain of Rio Grande do Sul close to 7000

yr BP may be correlated to this Serra Velha forest expansion, indicating a general increase of temperature and humidity (Tab. 1).

A short dry phase seems to follow, with a significant retraction of the forest and the herbaceous marsh indicators, and an increase of the adjacent dry field vegetation. Soon the favorable conditions for the forest development return with an increase of arboreal and herbaceous marsh vegetation and the reduction of dry soil species.

From the lowest part of zone III onwards, there is a significant expansion of the forest over the herbaceous marsh, beginning at about 6000 yr BP, when the latest forest expansion over the marsh seems to have taken place. Corresponding to this expansion, the herbaceous marsh vegetation recedes significantly, reinforcing these data. An accentuated increase of Poaceae in the upper half of zone III seems to be linked to anthropogenic factors, with environment alterations of the adjacent areas of marsh deposit. The same factors seem to have caused the forest to decline and the dry soil vegetation to expand in neighboring areas, as was registered in the upper part of this zone, towards the top of the core, in the last 47

Table 1 - Holocene palynological evidences in Serra Velha (present paper) and in the Coastal Plain of Rio Grande do Sul ( $^{14}\text{C}$  yr BP and estimated ages \*)

References	Accentuated marine transgression	Short phase of forest development	Maximum marine influence	Beginning of the latest forest expansion
Neves (1998)			$3910 \pm 100$	$3750 \pm 70$
Cordeiro & Lorscheitter (1994)			$4080 \pm 120$	after 4000 *
Neves & Lorscheitter (1995)				$4120 \pm 90$
Lorscheitter & Dillenburger (1998)			5000 *	after $4830 \pm 120$
Werneck & Lorscheitter (2001)	$7020 \pm 70$		5000 *	after 4000 *
Medeanic <i>et al.</i> (2001)	$7370 \pm 150$		6000 - 5500 *	
Serra Velha		$7800^* - 7280 \pm 60$		6000 *

cm of the sequence. Compared to the palynological results obtained for the Coastal Plain of Rio Grande do Sul (Table 1), it becomes evident that the beginning of the latest expansion of the Atlantic rain forest in Serra Velha - at about 6000 yr BP - is previous to the one which occurred in distinct places of the Coastal Plain, where the beginning of the latest forest expansion happened from 4000 yr BP onwards, after a phase of maximum marine influence. Thus the palynological data of Serra Velha show the importance of the forest vegetation of Serra Geral foothills in the establishment of the Atlantic rain forest in the Coastal Plain, through a possible west-east migration, already mentioned by Rambo (1950, 1951) when studying this regional flora.

### CONCLUSIONS

The obtained results indicate the genesis of the marsh forest by hydrosere from a water body, with a significant filling up process at the beginning of the Holocene, probably due to plant colonization caused by the climate amelioration. Data show a significant tendency in the development of the regional forest vegetation, estimated at about 7800 - 7280 ± 60 yr BP, when a considerable forest expansion over the marsh took place. The geographic formation of valleys, surrounded by higher areas of sandstone must have greatly contributed to this tendency, together with a general increase of temperature and humidity. Afterwards, a short dry phase makes the forest vegetation recede. At about 6000 yr BP, the latest considerable forest expansion over the marsh seems to begin, indicating humidity conditions. Compared to the coastal marsh forest development in Rio Grande do Sul (Table 1), this latest forest expansion in the Serra Velha region seems to be clearly older. Therefore, zones of Serra Geral foothills probably provided conditions for the Coastal Plain forest colonization,

after a maximum marine transgression, through a west-east migration. Further palynological studies and <sup>14</sup>C dates in the Serra Velha region will most certainly help clarify this subject even more.

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