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Relative Sea Level Variations and Climatic Evolution in Southeastern and Southern Brazil During the Late Holocene

JEAN-PIERRE YBERT[1], WALTER MARESCHI BISSA[2] & MIRYAM KUTNER[3]

[1] IRD, 32 Avenue Henri Varagnat, 93143 Bondy cedex, France.
[2] Museu de Arqueologia e Etnologia, Av. Prof. Almeida Prado, 1466. Cidade Universitária. 05508-900 São Paulo, Brazil.
[3] Instituto Oceanográfico, Praça do Oceanográfico, 191. Cidade Universitária. 05508-900 São Paulo, Brazil.

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Abstract - Analysis of organic sediments from a swamp forest on the coastal plain of São Paulo State (southeastern Brazil) has been carried out. Diatom and pollen contents from the same samples were analysed. This study allowed reconstruction of the regional palaeoenvironment during the Late Holocene. From at least 4400 to 3250 yr BP the site was a lagoon surrounded by a relatively open forest. At ca. 3250 yr BP, after the retreat of the sea, a swamp forest occupied the area. This swamp forest remains until the present day. It was locally altered during a short period between ca. 1400 and 775 yr BP when, due to a rise in groundwater, a fresh water lake or marsh was formed. The climate was similar to the present during the whole Late Holocene, except for three slightly more humid episodes: 3250-2600, around 2000, and 1400-775 yr BP. No human impact on the vegetation was recorded during the Late Holocene. Our results show that sea level was higher than the present zero level from 4400 to 3250 yr BP, contradicting a widely accepted relative sea level trend that suggests that at least two important negative sea level oscillations occurred during the Holocene (4100-3800 and 3000-2700 yr BP). Conversely, these results tend to confirm more recent studies that propose a continuously declining relative sea level trend. Comparison of our data with those from 24 sites situated in southeastern, southern and central Brazil show that the more humid episodes recorded at Cananéia-Iguape might be correlated with El Niño-like events. Trends in climatic evolution during the Late Holocene are opposite at north and south of 20°S latitude.

Keywords - Palaeoenvironment, Sea level variations, Late Holocene.

INTRODUCTION

Evolution of the relative sea level during the Late Holocene has been the object of many publications and controversies in the course of the last decades. Various curves representing these variations have been proposed, all based on the position and on the age of marine biological remains spread out on the seashore and on radiocarbon dating of shellmounds. It is admitted that sea level rose during the Late Pleistocene and the Early Holocene to reach a maximum of ca. 4 meters higher than the present zero around 5000 years BP. After that, two trends of evolution are proposed: one defining an irregular fall with important oscillations (Fairbridge, 1976; Martin *et al.*, 1979, 1984a, 1997); another one defining a regular fall until the present days (Angulo & Lessa, 1997; Angulo *et al.*, 1999). In this work, original proxy data are used to evaluate relative sea level variations. Analyses of pollen and diatoms of a core from the coastal plain of São Paulo State sheds a new light on the question.

This study is also important to improve the knowledge of the climatic evolution along the littoral, for the same material has been used to reconstruct the regional environmental and climatic evolution. Until now, the available data are mainly from Rio Grande do Sul State, at Terra de Areia (Neves & Lorscheitter, 1991), Lagoa dos Patos (Cordeiro & Lorscheitter, 1994) and Capão do Leão (Neves & Lorscheitter, 1997), from Santa Catarina State, in the south of Joinville (Behling, 1995a), and from Rio de Janeiro State, between Saquarema and Cabo Frio (Scheel-Ybert, 2000; Tasayco-Ortega, 1996). Nothing was known from the littoral of Paraná and São Paulo States.

Moreover, comparison of the climatic evolution trends in Southern, Southeastern and Central regions of Brazil might allow a best knowledge of its global evolution.

AREA OF STUDY

The area of study is located in the sedimentary coastal plain of Cananéia-Iguape, at Fazenda Boa Vista, 15-km away from Iguape (24°36'15''S - 47°38'00''W) (Fig. 1).

The climate is tropical sub-warm and super-humid, with no dry season (Nimer, 1989). The annual mean temperature is 23°C (up to 38-40°C in December and January). The absolute minimum is of 2 to 4°C.

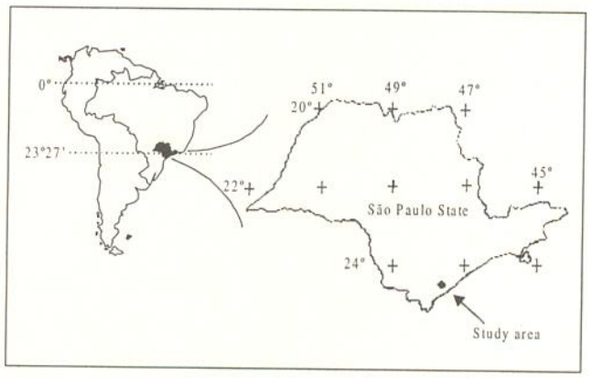

Figure 1 - Localization of the study area in the coastal plain of São Paulo State, Brazil.

Precipitation in the coastal area is 2000 mm/yr, concentrated mostly between January and March.

The local vegetation is a swamp forest with trees up to 20 meters. Myrtaceae and Lauraceae are the best represented families. The forest is characterised by a great abundance of epiphytes belonging to families Bromeliaceae, Cactaceae, Orchidaceae, Polypodiaceae and Araceae (Catharino, 1986). Variations in the relative ground water level of the swamp forest create secondary associations in which Cyperaceae and Melastomataceae are predominant, followed by Pteridophyta and Briophyta (*Sphagnum*). *Alchornea, Rapanea* and Moraceae are abundant in the clearings and forest edges.

The ground, constantly flooded, presents partially decomposed plants accumulation. In the central part of the swamp, the peat layer reaches 5 m of organic sediment, with pH varying from 2,0 to 3,0. Altitude of the peat surface is +4 metres.

MATERIAL AND METHODS

Sediments were collected on the bank of a drainage trench at Fazenda Boa Vista, in the southwestern margin of the peat bog. The first 109 cm were collected directly at the slope of the trench, by parallelepiped cuts of sediment. After this point, which corresponds to the water level in the trench, a piston corer was used. The total thickness of sediments collected reached 280 cm.

From the core surface until 100 cm, sediment is a peat presenting many plant remains. From 100 to 185 cm, it is a compact black clayey peat; from 185 to 225 cm, a dark olive green organic clay; from 225 to 280 cm, a grey compact clay. The sandy substratum has been reached at 280 cm.

Pollen analyses have been carried out by Bissa (Bissa, 1998; Bissa *et al.*, 2000; Ybert *et al.*, in revision) on 1-cm thick samples, 10 cm apart from each other. Treatment of samples followed the standard method established by Ybert *et al.* (1992), i.e., chemical attack with HCl 10 % for elimination of carbonates, KOH 10 % for elimination of humic acids and dispersion of organic matters, acetolysis, and separation of minerals with Cl_2Zn dense solution.

Six *Lycopodium* spore tablets were added to each sample at the beginning of the treatment in order to calculate the overall pollen concentration per unit of volume and weight of sediment.

The same levels were prepared for diatom analyses by Kutner (Bissa, 1998; Bissa *et al.*, 2000; Ybert *et al.*, in revision). Von Stosch technique (Carmelo, 1997) was applied: washing the sample in distilled water, decanting and removing the water, adding 20 ml of nitric acid, warming it for 30 minutes and washing by decanting with distilled water to obtain a neutral pH. Plates were mounted with resin (Naphrax).

Four ^{14}C-radiometric dates were obtained on total organic matter. They situate the studied sediment in the Upper Holocene, between ca. 4400 years BP and the present (Fig. 2).

This work presents a reinterpretation of the previous works by Bissa (1998) and Bissa *et al.* (2000, in revision).

RESULTS

Analytical results

The results of diatom (Tab.1) and pollen analyses (Fig. 2, A-C) allow the differentiation of five zones with the following characteristics:

Zone 1 – from the base to 200 cm (ca. 4400-3250 yr BP): presence of sea diatoms and low concentration of pollen and spores (Fig. 2-C). Relative frequency of herbaceous pollen is higher than in the upper part of the core. Pioneer and open environment species, such as *Alchornea* (30 to 50 %), Moraceae and Ulmaceae are abundant (Fig. 2-A).

Zone 2 – from 200 to 120 cm (ca. 3250-2600 yr BP): there is a significant increase of Myrtaceae, Palmae and *Byrsonima* pollen. Heliophylous species, non arboreal pollen and Pteridophyta spores decrease (Fig. 2-B).

There are no diatom in this zone, neither in the rest of the core.

Zone 3 – from 120 to 70 cm (ca. 2600-1400 yr BP): percentages of *Ilex* sp. increase, while heliophylous species decrease still more. Pteridophyta spores present very low percentages. Pollen diversity is lower than in the other zones, although there is a peak of arboreal pollen (*Laplacea* and *Byrsonima*) in the middle part of the zone.

Zone 4 – from 70 to 40 cm (ca. 1400-775 yr BP): there is an increase of *Alchornea*, Ulmaceae, *Ilex*, *Rapanea*, and mainly Melastomataceae and Pteridophyta. Cyperaceae and *Sphagnum* spores are very abundant.

Zone 5 – from 40 cm to the top (ca. 775 yr BP to present): all pollen and spores of flooded environment disappear. Arboreal plants pollen increase markedly.

Environmental and climatic evolution

Studies concerning the relative mean sea level evolution indicate it raised during the early Holocene to a maximum higher than the present zero. According to different authors, this maximum was either of +2 to +2,5 m, around 4500 yr BP (Fairbridge, 1976), or of + 3,5 to +4 m, at 5100 yr BP (Martin *et al.*, 1979, 1984a; Angulo & Lessa, 1997). All these authors postulate that sea level was lower than +2 to +2,5 m after ca. 3250 yr BP.

Our results, in agreement with these data, indicate that a cove or a lagoon occupied the area of study during the period corresponding to pollen zone **1**, i.e., from ca. 4400 to 3250 yr BP. An herbaceous land probably surrounded it. A relatively open forest grew over the Pleistocene beach ridges and over the hills. Climate was relatively humid.

After ca. 3250 yr BP, the cove or lagoon disappeared definitively from the area. A swamp forest covered the region. Climate was slightly more humid than during the previous period.

Between ca. 2600 and 1400 yr BP, decrease of Pteridophyta and of plant diversity indicate a slightly drier climate, despite a short humid phase around 2000 yr BP. In spite of this small climatic change, the forest remained quite unaltered.

Between ca. 1400 and 775 yr BP, pollen data indicate the presence of a shallow fresh-water lake. The forest was locally altered but remained regionally present. Formation of the lake was probably due to a rise of the groundwater level, related with higher precipitation and with a more humid climate.

After ca. 775 yr BP the lake disappeared and the swamp forest reoccupied the area. The climate was slightly less humid again.

DISCUSSION

Relative sea level variations

The presence of marine and brackish diatoms in the core pollen zone **1** indicates that the sea covered the area of study from at least 4400 yr BP to ca. 3250 yr BP.

The top of the core altitude is +4 m. Consequently, bottom altitude is +1,20 m, and the superior boundary of pollen zone 1 is at +1,90 m. This means that during all the period from ca. 4400 to 3250 yr BP, sea level remained at least 2-m higher than at present. This is in agreement with the sea level variation curves established for the coast of Cananéia-Iguape (Angulo & Lessa, 1997), and for Santa Catarina State (Angulo *et al.*, 1999) (Fig. 3-A). According to these authors, sea level dropped regularly from a maximum of +3,5 to +4 m, at 5100 yr BP until the present, when it reached the present zero.

Conversely, it is in disagreement with the curves proposing important negative oscillations during this period, e.g. ca. 4500-4250 yr BP (Fairbridge, 1976) (Fig. 3-B) or ca. 4100-3750 yr BP (Martin *et al.*, 1979, 1984a, 1997) (Fig. 3-C).

In all cases relative sea level was of approximately +2 m at 3250 yr BP, and lower afterwards. In the core, this date corresponds to the boundary between pollen zones 1 and 2, and to ceasing of the diatoms occurrence.

Regional climatic evolution

Late Holocene climatic evolution presented in this paper is in reasonable agreement with data obtained from Brazilian sites between 20° and 35°S latitude (Fig. 4). A wet climate was recorded since 4400 yr BP on the Cananéia-Iguape plain (Fig. 4, n° **10**; 24°36'S), with two slightly wetter episodes at ca. 2000 and between ca. 1400-750 yr BP.

A wet climate characterized the Southern Brazil from ca. 5000/4100 yr BP to the present, with increase of moisture during the 1000 last years. This is verified in the southern coastal plain (**1**; 31°47'S) (Neves & Lorscheitter, 1997), Lagoa dos Patos (**2**; 30°50'S) (Cordeiro & Lorscheitter, 1994), northern coastal

Table 1 - Diatoms distribution in the Cananéia-Iguape core, according to the habitat of each taxon.

Environment	Species	Stratigraphic level (in cm)							
		210	220	230	240	250	260	270	280
Marine	*Actinocyclus* sp.			*			*		
	Actinoptychus hookeri					*			
	Actinoptychus senarius				*				
	Actinoptychus splendens	*	*		*		*		
	Actinoptychus vulgaris				*		*		
	Biddulphia rhombus						*		
	Diploneis bombus		*			*		*	
	Nitzschia panduriformes				*				
	Polymixus coronalis					*			
	Raphoneis sp.						*		
	Thalassiosira sp.							*	*
	Triceratium patagonicum			*	*	*			
Marine littoral or Estuarine	*Cyclotella stylorum*	*	*	*					
	Paralia sulcata	*	*	*	*	*	*	*	*
	Triceratium favus	*	*	*	*		*		
Marine littoral, Estuarine or Continental brackish water	*Achnanthes brevipes*					*			*
	Achnanthes longipes							*	*
	Cyclotella striata				*				
	Surirella rorata					*	*	*	*
	Terpsinoe musica		*	*	*				
Fresh water	*Eunotia diodon*							*	*
Continental	*Cocconeis placentula*					*			*
Unknown	*Achnanthes* sp.							*	
	Actinoptychus sp.							*	
	Amphora sp.						*		
	Caloneis sp.								*
	Cocconeis sp.			*	*	*			
	Coscinodiscus sp.		*	*	*		*	*	*
	Cyclotella sp.						*	*	
	Cymbella sp.					*		*	*
	Epithemia sp.				*			*	*
	Eunotia sp.		*	*	*	*	*		*
	Gomphonema sp.		*					*	
	Gyrosigma sp.							*	
	Melosira sp.	*	*		*				*
	Nitzschia sp.					*	*	*	*
	Pinnularia sp.						*	*	*
	Synedra sp.		*	*	*		*	*	*

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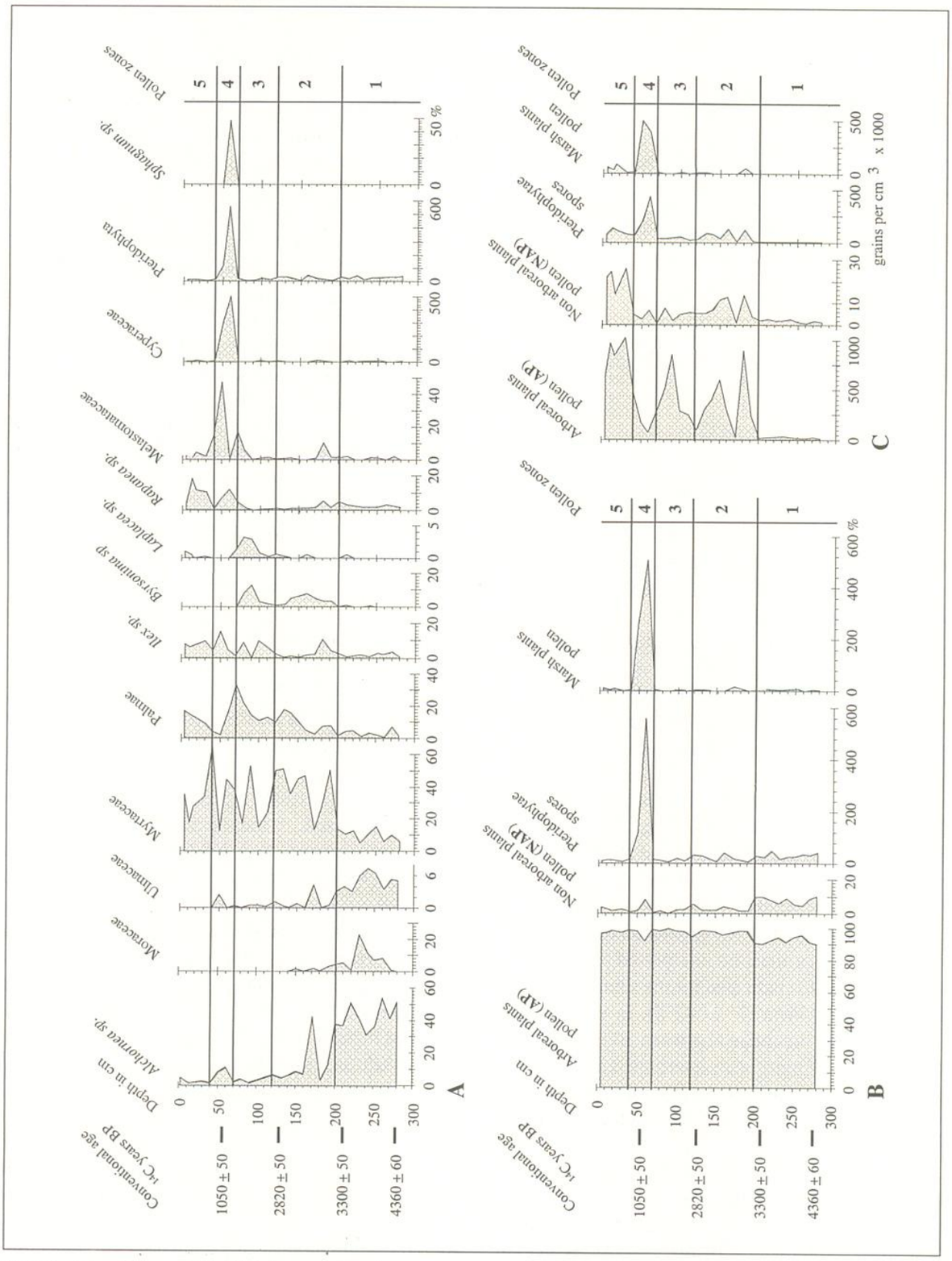

Figure 2 - Pollen diagrams. A) Detailed diagram, only major taxa are represented; B) Synthetic diagram; C) Absolute frequencies diagram.

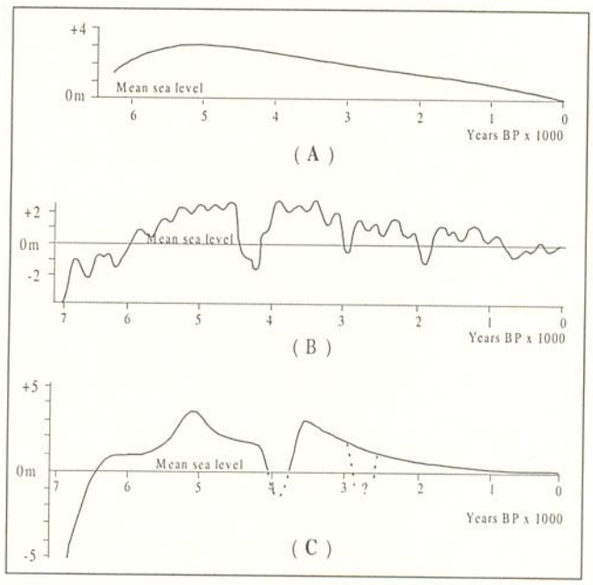

Figure 3 - Curves of relative sea level variation: (A) Littoral of Cananéia (after Angulo & Lessa, 1997); (B) Littoral of Cananéia-Iguape (after Martin *et al.*, 1979); (C) Littoral of Brazil (after Fairbridge, 1976).

plain (**3**; 29°33'S) (Neves & Lorscheitter, 1991) and in the inland plateau (**4**; 29°24'S) (Behling *et al.*, 1999) of Rio Grande do Sul State.

On the Santa Catarina State southeastern highlands, the palynological data from three cores were interpreted as indicating a drier climate from 10,000 to 2900 yr BP (Behling, 1995a, table 3, pp. 147). However, the description of the Serra do Rio Rastro core palynological diagrams (**5**; 28°23'S) and the discussion (pp. 146) show that Atlantic pluvial forest elements increase markedly since ca. 6500 yr BP to the present. In Morro da Igreja core (**6**; 28°11'S), the author indicates a decrease of Poaceae pollen grains and an increase of Atlantic pluvial forest elements from ca. 7000 to 3000 yr BP. An expansion of the Atlantic pluvial forest, that must be interpreted as an increase of humidity, is also indicated for the same pollen zone at Serra da Boa Vista (**7**; 27°42'S). In view of these facts, the period comprised between 10,000/7000 and 3000/2500 yr BP must be re-interpreted as wetter than during the previous period. A drier episode is recorded between 2500 and 1500 yr BP, then another wet episode from 1500 yr BP to the present.

A wet climate was also postulated between ca. 4600 and 3500 yr BP for the coastal plain in the northern Santa Catarina State (**8**; 26°25'S), followed by a drier climate (Behling, 1995a). However, according to the author, a hiatus of more than 2000 years may exist in the top of the core.

A wet climate was recorded from 9500 yr BP to present, with marked precipitation increases at ca. 2850 and 1530 yr BP, for Serra Campos Gerais (**9**; 24°40'S), northeastern Paraná State (Behling, 1997a).

Moisture increasing from ca. 4100 yr BP to the present, more accentuated between ca. 2600 and 450 yr BP, was recorded also in Morro de Itapeva (**13**; 22°47'S), São Paulo State (Behling, 1997b). Wet episodes were recorded from 8000 to 3500 yr BP and from 1500 yr BP to the present in the Upper Paraná Basin (**14**; 22°43'S), Paraná State (Stevaux, 2000).

No major changes of the vegetation occurred from 5500 to 1400 yr BP on the southeastern coast of Rio de Janeiro State (**11/12**; 22°49'-22°57'S), although wetter periods were recorded at 2300-2000 yr BP, based on archaeological charcoal analysis (Scheel-Ybert, 2000) and at 2300-2100 yr BP and 1000-600 yr BP, based on isotopic variations in lagoon carbonated sediments (Tasayco-Ortega, 1996).

As for Brazilian sites situated north of 20°S, the following trends of climatic evolution during the Late Holocene have been recorded:

A wet climate was recorded from ca. 8400 yr BP to the present, with three slightly less humid episodes, respectively at ca. 5000-4000, 3200-2400 and 1800-650 yr BP in Lake Dom Helvécio, Minas Gerais State (**16**; 19°46'S) (Ybert *et al.*, 2000).

Wet climate was recorded also at Lagoa dos Olhos (**17**; 19°38'S) and Lagoa da Serra (**20**; 19°00'S), respectively since ca. 6790 and 5000 yr BP to the present (Oliveira, 1992). No oscillations were recorded during this period. At Lagoa Santa (**18**; 19°30'S), an increase of moisture at ca. 4600 yr BP and between ca. 3000 and 1800 yr BP, then a slightly drier episode since ca. 1440 yr BP were recorded (Parizzi, 1998). Palynological analysis (Ledru *et al.*, 1994) and charcoal studies (Vernet *et al.*, 1994) proved the existence of a dry episode around 1000 yr BP at Lagoa Campestre, near Salitre (**19**; 19°00'S). A dry episode was also recorded in Serra do Espinhaço, at Córrego Contagem (**22**; 18°25'S), between ca. 2000 and 1000 yr BP (Servant *et al.*, 1989).

A progressively increasing moisture was recorded at Lago do Pires (**23**; 17°57'S) from ca. 8800 yr BP to the present (Behling, 1995b). However, the pollen diagram shows higher herbs frequencies and lower trees frequencies between ca. 2250 and 950 yr BP. This might indicate a slightly drier episode during this period. Increase of Myrtaceae, interpreted by this author as an indicator of higher humidity, is usually

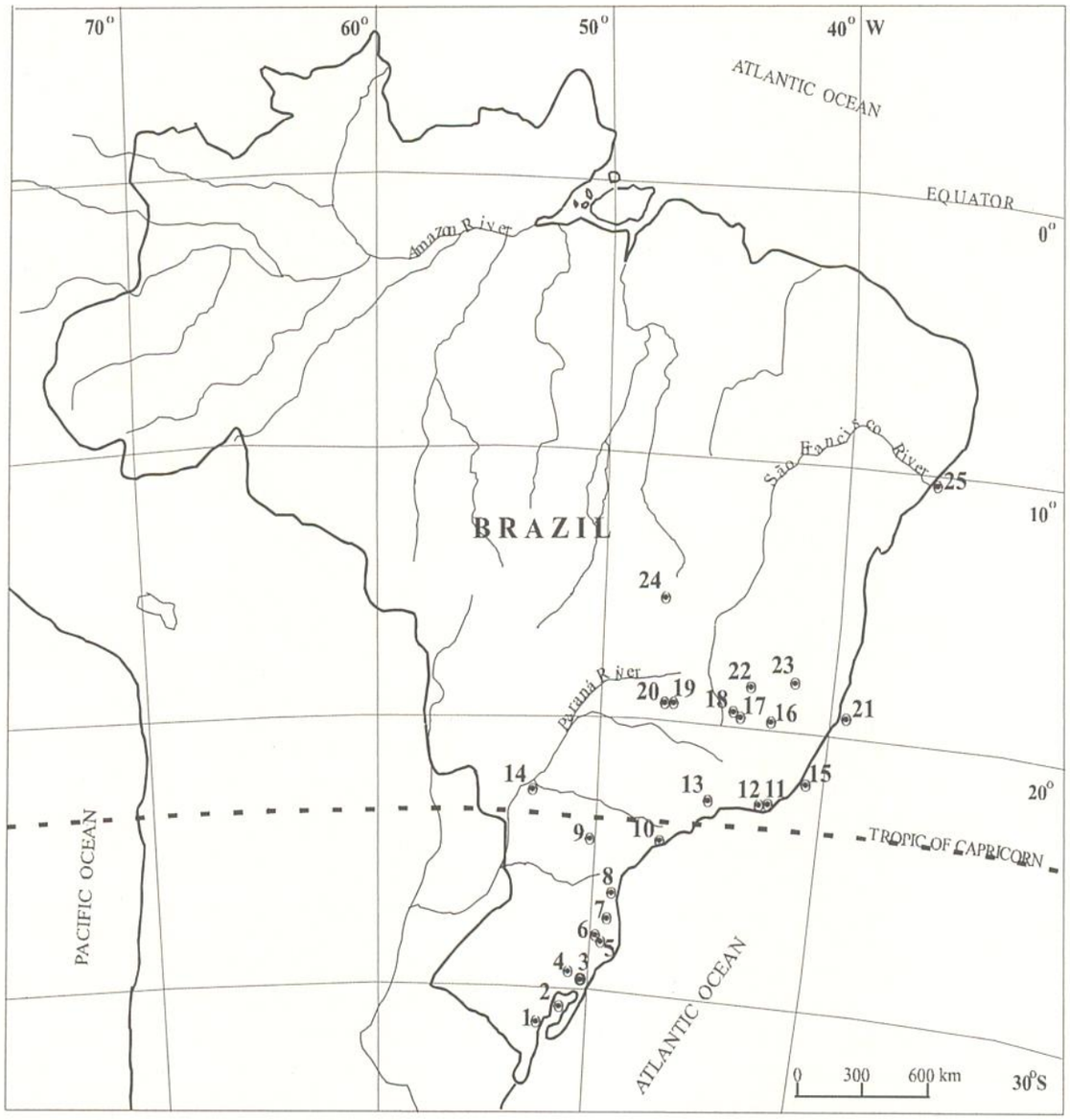

Figure 4 - Map of location of the referred sites:
1, Capão do Leão (31°48'S, 52°16'W), Neves & Lorscheitter (1997); 2, Lagoa dos Patos (30°51'S, 50°59'W), Cordeiro & Lorscheitter (1994); 3, Terra de Areia (29°33'S, 50°03'W), Neves & Lorscheitter (1991); 4, São Francisco de Paula (29°24'S, 50°34'W), Behling *et al.* (1999); 5, Serra do Rio Rastro (28°23'S, 49°33'W), Behling (1995a); 6, Morro da Igreja (28°11'S, 49°52'W), Behling (1995a); 7, Serra da Boa Vista (27°42'S, 49°09'W), Behling (1995a); 8, Poço Grande (26°25'S, 48°52'W), Behling (1995a); 9, Serra Campos Gerais (24°40'S, 50°13'W), Behling (1997); 10, Iguape (24°36'S, 47°38'W), Bissa *et al.* (in revision); 11, 12, Saquarema - Cabo Frio (22°53'-22°57'S, 42°03'-42°36'W), 11, Scheel-Ybert (2000); 12, Tasayco Ortega (1996); 13, Morro de Itapeva (22°47'S, 45°32'W), Behling (1997); 14, Porto Rico (22°43'S, 53°10'W), Stevaux (2000); 15, Paraiba do Sul River (22°S), Martin *et al.* (1984); 16, Lago Dom Helvécio (19°46'S, 42°36'W), Ybert *et al.* (2000); 17, Lagoa dos Olhos (19°38'S, 43°54'W), Oliveira (1992); 18, Lagoa Santa (19°30'S, 44°07'W), Parizzi (1993); 19, Lagoa Campestre, Salitre (19°00'S, 46°46'W), Ledru *et al.* (1994); Vernet *et al.* (1994); 20, Lagoa da Serra Negra (19°00'S, 46°50'W), Oliveira (1992); 21, Doce River (19°S), Martin *et al.* (1992); 22; Córrego Contagem (18°25'S, 43°40'W), Servant *et al.* (1989); 23, Lago do Pires (17°57'S, 42°13'W), Behling (1995b); 24, Vereda de Águas Emendadas (15°34'S, 47°35'W), Barberi *et al.* (2000); 25, São Francisco River (10°S), Martin *et al.* (1984).

considered as an indicator of lower humidity (Absy, 1979). This family is abundant in very different vegetation types, such as pluvial and flooded forests and "restingas", so it cannot be taken in consideration for climatic interpretation.

An increase of humidity was recorded from ca. 7000 yr BP onwards at Vereda de Águas Emendadas, in central Brazil (**24**; 15°43'S) (Barberi *et al.*, 2000). Three or more extensive episodes of fire have been recorded after 2600 yr BP, the more important around 2600 and at ca. 1300 yr BP.

As we can see, all the southeastern and southern Brazilian records indicate an increase of moisture during the Holocene. In the Late Holocene, slight oscillations to more humid conditions were recorded at ca. 2500-2000 and 1500-500 yr BP south of 20°S latitude. On the contrary, drier episodes were recorded for the same periods north of 20°S latitude.

This inversion in the trends of climatic evolution may be explained by the blockage of polar advections near 20°S latitude during El Niño-like conditions (Martin *et al.*, 1984b, 1991, 1993).

During the 5000 last years, the coastal sand transport in Paraiba do Sul River coastal plain (**15**; 22°S) was from south to north; in São Francisco River's mouth (**25**; 10°S) it was from north to south; and in Doce River coastal plain (**21**; 19°S) it was alternatively south-north or north-south. Inversions of transport orientation at Rio Doce River's mouth are related to El Niño-like conditions that blocked the polar advections between 19 and 22°S. These events provoked precipitation increase southwards and decrease northwards. Periods of El Niño-like conditions were recorded around 2300 and 1300 yr BP on Rio Doce River's coastal plain (Martin *et al.*, 1993). At the same periods, humid episodes were recorded in sites **1** to **14** and dry episodes in sites **16** to **24**.

CONCLUSIONS

Pollen and diatom studies on peat sediments from the coastal plain of Iguape, São Paulo State, showed that the region was occupied by a cove or lagoon from at least 4400 to ca. 3250 yr BP. Sea level remained at least two meters higher than the present-day level until 3250 yr BP, and lower since then. The progressive retreat of the sea led to the disappearance of the lagoon and favored the installation of a swamp forest.

Climate was very stable during the 4400 latest years, as only three slightly more humid periods have been recorded. The latest and most significant, around 1000 yr BP, was accompanied by a rising of the ground water level and by the formation of a swamp. These climatic variations were not sufficient to induce significant changes in the regional vegetation and the forest formations were always predominant.

The more humid episodes, around 2000 and 1000 years BP, are correlated with equivalent humid episodes recorded in various sites located south of 20°S latitude, and with dry episodes recorded in sites located north of this latitude. These episodes are probably related to El Niño-like events.

REFERENCES

Absy, M.L. 1979. **A palynological study of Holocene sediments in the Amazon basin.** Amsterdam. 86 p. Tese de Doutorado, Universidade de Amsterdam, Holanda.

Angulo, R.J. & Lessa, G. 1997. The brazilian sea level curves: a critical review with emphasis on the curves from the Paranaguá and Cananéia regions. **Marine Geology, 140**: 141-166.

Angulo, R.J.; Giannini, P.C.F.; Suguio, K. & Pessenda, L.C.R. 1999. Relative sea-level changes in the last 5500 years in southern Brazil (Laguna – Imbituba region, Santa Catarina State) based on vermetid ^{14}C ages. **Marine Geology, 159**: 323-339.

Barberi, M.; Salgado-Labouriau, M.L. & Suguio, K. 2000. Paleovegetation and paleoclimate of "Vereda de Águas Emendadas", central Brazil. **Journal of South American Earth Sciences, 13**: 241-254.

Behling, H. 1995a. Investigations into the Late Pleistocene and Holocene history of vegetation and climate in Santa Catarina (S Brazil). **Vegetation History and Archaeobotany, 4**: 127-152.

Behling, H. 1995b. A high resolution Holocene pollen record from Lago do Pires, SE Brazil: vegetation, climate and fire history. **Journal of Paleolimnology, 14**: 253-268.

Behling, H. 1997a. Late Quaternary vegetation, climate and fire history of the *Araucaria* forest and campos region from Serra Campos Gerais, Paraná State (S Brazil). **Review of Palaeobotany and Palynology, 97**: 109-121.

Behling, H. 1997b. Late Quaternary vegetation, climate and fire history from the tropical mountain region of Morro de Itapeva, SE Brazil. **Palaeogeography, Palaeoclimatology, Palaeoecology, 129**: 407-422.

Behling, H.; Bauer, S. & Neves, P. 1999. Holocene environmental changes from São Francisco de Paula region in southern Brazil. In: CONGRESSO DA ASSOCIAÇÃO BRASILEIRA DE ESTUDOS DO QUATERNÁRIO, 7., 1999, Porto Seguro. **Resumo...** Porto Seguro. p. 1.

Bissa, W.M. 1998. **Reconstituição dos paleoambientes de uma planície holocênica no curso inferior do Rio Ribeira (Município de Iguape, SP)**. São Paulo. 60 p. Dissertação de Mestrado, FFLCH, Universidade de São Paulo.

Bissa, W.M.; Ybert, J.-P.; Catharino, E.L.M. & Kutner, M. 2000. Evolução paleoambiental na planície costeira do Baixo Ribeira durante a ocupação sambaquieira. **Revista do Museu de Arqueologia e Etnologia, 10**: 89-102

Carmelo, R.T. 1997. **Identifying marine phytoplankton**. Academic Press, 858 p.

Catharino, E.L.M. 1986. Composição florística e fitofisionomia de uma Mata de Turfeira (Floresta Pluvial Tropical Atlântica) localizada em uma planície quaternária recente. **Internal report**, Escola de Agricultura "Luiz de Queiroz", Brasil, 38 p.

Cordeiro, S.H. & Lorscheitter, M.L. 1994. Palynology of Lagoa dos Patos sediments, Rio Grande do Sul, Brazil. **Journal of Paleolimnology, 10**: 35-42.

Fairbridge, R.W. 1976. Shellfish-eating preceramic indians in coastal Brazil. **Science, 191**(4225): 353-359.

Ledru, M.P.; Behling, H.; Fournier, M.; Martin, L. & Servant, M. 1994. Localisation de la forêt *d'Araucaria* du Brésil au cours de l'Holocène. Implications paléoclimatiques. **Comptes Rendus de l'Academie de Sciences Paris, Sciences de la vie, 317**: 517-521.

Martin, L.; Suguio, K. & Flexor, J.M. 1979. Le Quaternaire marin du littoral brésilien entre Cananéia (SP) et Barra de Guaratiba (RJ). In: INTERNATIONAL SYMPOSIUM ON COASTAL EVOLUTION IN THE QUATERNARY, 1978, São Paulo. **Proceedings...** São Paulo, p. 296-331.

Martin, L.; Suguio, K. & Flexor, J.M. 1984a. Informações adicionais fornecidas pelos sambaquis na reconstrução de paleolinhas de praia quaternária: exemplo da costa do Brasil. **Revista de Pré-História, USP, Brasil, 6**: 128-147.

Martin, L.; Flexor, J.M.; Vernon, K. & Cavalcanti, I.F.A. 1984b. Inversions du sens du transport littoral enregistrées dans les cordons littoraux de la plaine côtière du Rio Doce (Brésil). Possible liaison avec des modifications de la circulation atmosphérique. **Comptes Rendus de l'Academie de Sciences Paris**, Série II, **298**(1): 25-27.

Martin, L.; Flexor, J.M. & Suguio, K. 1991. Possible changes in the Holocene wind pattern recorded on southeastern brazilian coast. **Boletim do Instituto de Geologia da Universidade de São Paulo, 8**: 117-131. (Special Publication).

Martin, L.; Fournier, M.; Mourguiart, P.; Sifeddine, A.; Turcq, B.; Absy, M.L. & Flexor, J.M. 1993. Southern oscillation signal in South americam palaeoclimatic data of the last 7000 years. **Quaternary Research, 39**: 338-346.

Martin, L.; Bittencourt, A.C.S.P.; Dominguez, J.M.L.; Flexor, J.M. & Suguio, K. 1997. Oscillações ou não oscillações eis a questão. In: CONGRESSO DA ASSOCIAÇÃO BRASILEIRA DE ESTUDOS DO QUATERNÁRIO E REUNIÃO SOBRE O QUATERNÁRIO DA AMÉRICA DO SUL, 6., 1997, Curitiba. **Resumo expandido...** Curitiba. p. 99-104.

Neves, P.C.P. & Lorscheitter, M.L. 1991. Upper Quaternary palaeoenvironments in the Northern Coastal Plain of Rio Grande do Sul, Brazil. **Quaternary of South America and Antartic Peninsula, 9**: 39-67.

Neves, P.C.P. & Lorscheitter, M.L. 1997. Palinologia de sedimentos de uma mata tropical paludosa na Planície Costeira Sul do Rio Grande do Sul, Brasil. In: CONGRESSO DA ASSOCIAÇÃO BRASILEIRA DE ESTUDOS DO QUATERNÁRIO E REUNIÃO SOBRE O QUATERNÁRIO DA AMÉRICA DO SUL, 6., 1997, Curitiba. **Resumo expandido...** Curitiba. p. 341-344.

Nimer, E. 1989. **Climatologia do Brasil**. 2ª ed. IBGE, Rio de Janeiro, Brasil. 421 p.

Oliveira, P.E. de. 1992. **A palynological record of Late Quaternary vegetational and climatic change in southeastern Brazil.** Ohio. 238 p. Dissertation PhD, Graduate School of the Ohio State University, U.S.A.

Parizzi, M.G.; Salgado-Labouriau, M.L. & Kohler, H.C. 1998. Genesis and environmental history of Lagoa Santa, southeastern Brazil. **The Holocene, 8**(3): 311-321.

Scheel-Ybert, R. 2000. Vegetation stability in the Southeastern Brazilian coastal area from 5500 to 1400 ^{14}C yr BP deduced from charcoal analysis. **Review of Palaeobotany and Palynology, 110**: 111-138.

Servant, M.; Fournier, M.; Soubiès, F.; Suguio, K. & Turcq, B. 1989. Sécheresse holocène au Brésil (18-20° latitude Sud). Implications paléométéorologiques. **Comptes Rendus de l'Academie de Sciences Paris**, Série II, **309**: 153-156.

Stevaux, J.C. 2000. Climatic events during the Late Pleistocene and Holocene in the Upper Parana River: Correlation with NE Argentina and South-Central Brazil. **Quaternary International, 72**: 73-85.

Tasayco-Ortega, L.A. 1996. **Variations paléohydrologiques et paléoclimatiques d'une région d'upwelling au cours de l'Holocène : enregistrement dans les lagunes côtières de Cabo Frio (État de Rio de Janeiro, Brésil)**. Paris. 321 p. Thèse de Doctorat, Université Pierre et Marie Curie, Paris, France.

Vernet, J.L.; Wengler, L.; Solari, M.E.; Ceccantini, G.; Fournier, M.; Ledru, M.P. & Soubiès, F. 1994. Feux, climats et végétations au Brésil central durant l'Holocène: les données d'un profil de sol à charbons de bois (Salitre, Minas Gerais). **Comptes Rendus de l'Academie de Sciences Paris**, Série II, **319**: 1391-1397.

Ybert, J.-P.; Salgado-Labouriau, M.L.; Barth, O.M.; Lorscheitter, M.L.; Barros, M.A.; Chaves, S.A.M.; Luz, C.F.P.; Ribeiro, M.; Scheel, R. & Vicentini K.F. 1992. Sugestões para padronização da metodologia empregada em estudos palinológicos do Quaternário. **Revista do Instituto Geológico, São Paulo, Brasil, 13**(2): 47-49.

Ybert, J.-P.; Turcq, B.; Albuquerque, A.L. & Cocquit, Ch. 2000. Évolution paléoécologique et paléoclimatique holocène dans la région moyenne du Rio Doce (Minas Gerais, Brésil) déduite de l'analyse palynologique de deux carottes du lac Dom Helvécio. In: Servant, M. & Servant-Vildary, S. (eds.). **Dynamique à long terme des écosystèmes forestiers intertropicaux**. UNESCO, Paris. p. 413-421.

Ybert, J.-P.; Bissa, W.M.; Catharino, E.L.M. & Kutner, M. *In revision*. Environmental and sea level variation on the southearstern brazilian coast during the Late Holocene, with comments on prehistoric human occupation. **Palaeogeography, Palaeoclimatology, Palaeoecology.**