INTEPROXY RECORDS OF CHANNEL DYNAMICS AND HOLOCENE VEGETATION CHANGES IN THE SOUTHEASTERN AMAZON REGION

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1. INTRODUCTION

Several studies concerning the Holocene history of forest-savanna dynamics in Amazonia, mainly based on pollen, spore and isotopic data, indicate that during the early and mid-Holocene the savanna occupied a much larger area, probably in response to a drier climate. During the late Holocene, arboreal vegetation became more prominent due to the return of more humid climate conditions, most likely similar to those prevailing today (e.g. Pessenda et al., 1998; Behling and Costa, 2000; Pessenda et al., 2004). However, vegetation changes occur on a variety of scales, both temporal and spatial, and not all such changes are necessarily due to climate variation. Plant successional stages and natural morphological changes inherent to the depositional sedimentary environment make interpretation of the pollen record complex. Therefore, facies analyses, mineralogical, chemical, $\delta^{13}C$, $\delta^{15}N$ and C/N records must be used in conjunction with pollen and spore data since they provide powerful information relating to sedimentary processes, siliciclastic and organic matter sources and vegetation patterns which allow the isolation of climatic signals from nonclimatic noise and permit a better interpretation of the main processes acting on vegetation changes (e.g. Miall, 1992; Boutton et al., 1998). This work presents a detailed description of a sediment core using sedimentary facies, mineralogical, chemical, pollen, spore, $\delta^{13}C$, $\delta^{15}N$ and C/N data as well as radiocarbon dates of lacustrine deposits located near the Tocantins River in northern Brazil. The goal is to identify and discuss the relationship between the vegetation change patterns and the depositional system associated to the climatic changes recorded during the Holocene in the Amazon.

2. MATERIALS AND METHODS

The study site is located near the town of Marabá, between the Itacaiúnas and Tocantins Rivers. The geology is mainly represented by Archean-Proterozoic igneous and metasedimentary rocks of the Itacaiúnas and Araguaia Belt (Abreu, 1978). A lower segment of the Parnaíba Basin occurs as Cretaceous deposits of the Itapecuru Group (Rossetti and Truckenbrodt, 1997). These deposits are overlaid by Holocene alluvial sediments near the main river courses. The flora is represented by dense and open ombrophylous forest with canopy higher than 30 m. The sediment core was taken to a depth of 100 cm using a Russian Sampler in a small floodplain lake (hereafter denominated Lake Marabá, LM) surrounded by freshwater vegetation in the vicinity of the town of Marabá and the Tocantins River. Facies analysis included descriptions of color, lithology, texture and structures. The mineralogical identification was conducted by X-ray powder diffraction, using a PANalytical diffractometer model PW 3040, with records interpreted using X'Pert HighScore 2.1 software with ICDD. The chemical composition was reported on 0.2g sample analyzed by ICP-OES following a Lithium metaborate/tetrabortate fusion and dilute nitric digestion on Acme Analytical Laboratory. The data similarity analysis was performed by Single Linkage and Pearson product-moment correlation coefficient. Pollen and spore, $\delta^{13}C$, $\delta^{15}N$ and elementar C and N (C/N) analysis were conducted by Colinvaux et al. (1999) and Pessenda et al. (2004) standard methods. Two bulk samples of ~ 2g each were analyzed by Accelerator Mass Spectrometry (AMS) at the University of Erlangen (Nürnberg, Germany).

3. RESULTS AND DISCUSSION

The sediment core consists of massive to cross-laminated sand and laminated mud, with peat material in the upper segment. These lithologies are partially organized into a fining upward sequence. Furthermore, mineralogical, chemical, pollen, spore, $\delta^{13}C$, $\delta^{15}N$ and C/N records were added to facies characteristics in order to define one facies association (*Cut-off lake - upper deposit – COL*; Figure 1).

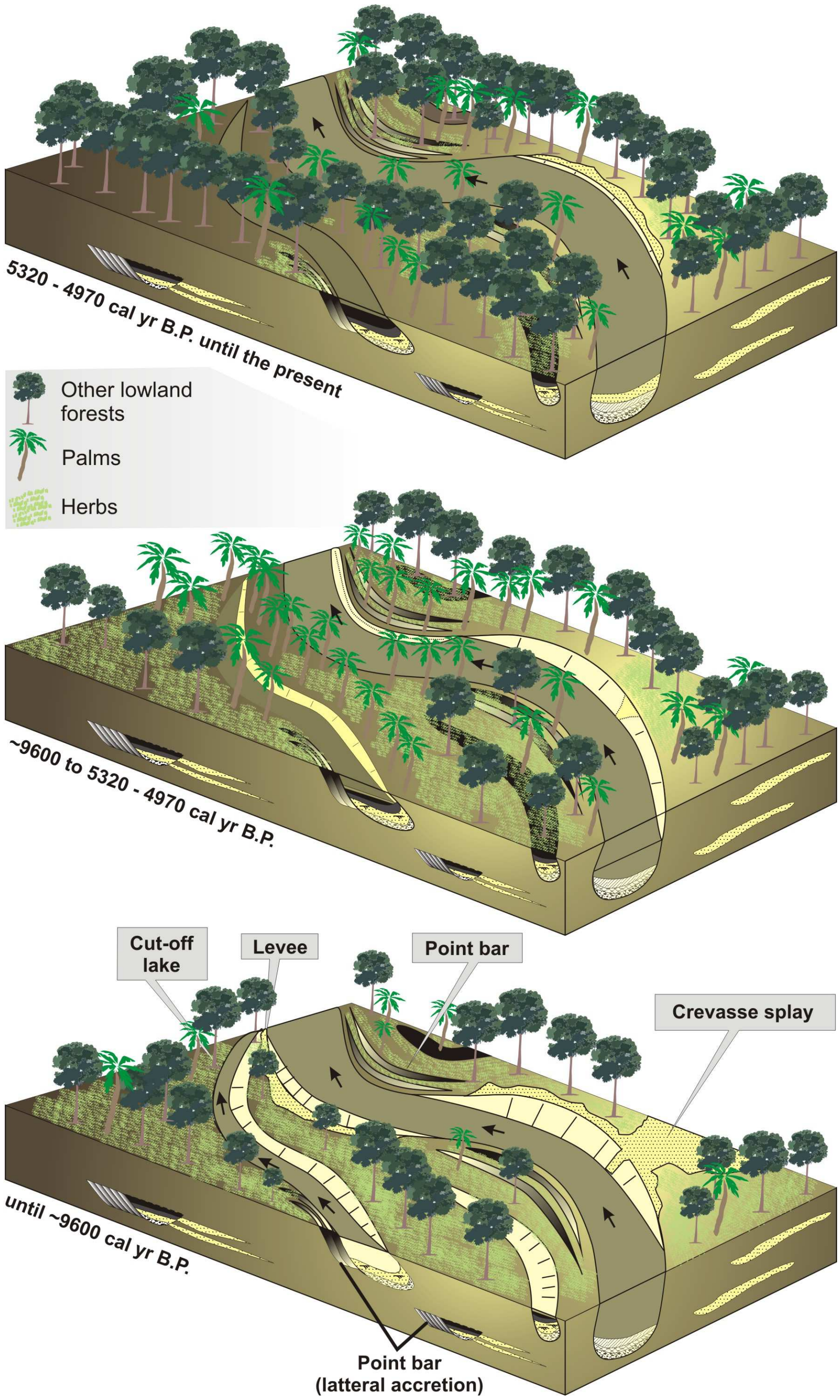

Figure 1: Schematic representation of successive phases of sediment accumulation and vegetation change in the study area, according to climate and lake fluctuations in a stationary floodplain.

The integrated data allowed the identification of three main phases of vegetation dynamics and lake-level fluctuations at the study site (Figure 1). During Phase 1 (>~9600 cal yr B.P.), as the deposition of sand by traction decreased, the channel was being disconnected from its main course. The relationship between $\delta^{13}C$ and C/N indicates a strong contribution of terrestrial woody species. Presumably, this organic matter is a product of the reworking of material from the margin of the channel. During Phase 2 (~9600 to 5320 - 4970 cal yr B.P.), the depression formed by the abandoned channel contributed to water accumulation and very low energy flows (Figure 1). It allowed the deposition of mud from suspension. The input of siliciclastic mud ceased and autochthonous organic material became prevalent starting from ~6400 cal yr B.P. Surrounding the lake, herbaceous vegetation dominated and the binary $\delta^{13}C$ and C/N reveals an increase in the contribution of freshwater DOC. Moreover, the development of *Mauritia* palm swamps around the lake is likely related to a rise in lake water level (e.g. Mayle et al., 2000). Phase 3 (5320 - 4970 cal yr B.P. until the present) marks the return of wetter conditions allowing the expansion of ferns and arboreal plants (Figure 3). The increase in P_2O_5 suggests the presence of illite and adsorption of phosphorous on clay minerals. The preservation of pyrite indicates that stagnant water and reduced conditions were established in conjunction with the increase in freshwater organic matter input, as evidenced by greater total C and N and the relationship between $\delta^{13}C$ and C/N. The cut-off lake maintains a concave morphology that allows the accumulation of stagnant water and mud sediments. Considering the current study, the evolution of Lake Marabá through its abandonment and filling according to the local conditions of hydrodynamics, geochemistry and vegetation may have followed a natural development. However, when considering the temporal correlation between the phases of lake development and the paleoclimatic records from the hinterland and littoral of the Amazon region (e.g. Pessenda et al., 1998; Behling and Costa, 2000; Pessenda et al., 2004), it is reasonable to highlight the climatic influence on the energy flow of the Tocantins River, and consequently on the process by which its channels were abandoned.

4. Conclusion

The interproxy records of the lacustrine deposit allowed the identification of three phases of sediment and organic matter accumulation associated to adjacent vegetation changes during the Holocene: Phase 1 (>~9600 cal yr B.P.), when the channel was gradually being disconnected from its main course, accumulating organic matter from terrestrial trees; Phase 2 (~9600 to 5320 - 4970 cal yr B.P.), during which the very low energy flows allowed the deposition of autochthonous organic mud from suspension. Herbaceous vegetation and *Mauritia* palm swamps dominated, followed by an increase in the contribution of freshwater DOC to the lake; Phase 3 (5320 - 4970 cal yr B.P. until the present) marks the return of wetter conditions characterized by the expansion of ferns and arboreal plants, and increased freshwater organic matter inputs into the lake with anoxic water conditions. Likely, peat formation and wetland development at Lake Marabá occurred through the interaction of geomorphologic changes following the natural filling process of an abandoned channel, under relatively dry and wet climate conditions during the Holocene.

REFERENCES

Abreu, F.A.M., 1978. Estratigrafia e Evolução Estrutural do Segmento Setentrional da Faixa de Dobramentos Paraguai-Araguaia. *Dissertação de Mestrado*, Universidade Federal do Pará, Belém. 90 pp.

Behling, H. and Costa, M.L., 2000. Holocene environmental changes from the Rio Curuá record in the Caxiuanã region, eastern Amazon Basin. *Quaternary Research* vol. 53, pp. 369-377.

Boutton, T.W., Archer, S.R., Midwood, A.J., Zitzer, S.F., Bol, R. 1998. $\delta^{13}C$ values of soil organic carbon and their use in documenting vegetation change in a subtropical savanna ecosystem. *Geoderma* vol. 82, pp. 5-41.

Colinvaux, P.A., De Oliveira, P.E. & Patiño, J.E.M. 1999. *Amazon Pollen Manual and Atlas - Manual e Atlas Palinológico da Amazônia*. Amsterdam: Hardwood Academic, 332 pp.

Mayle, F.E., Burbridge, R., & Killeen, T.J., 2000. Millennial-Scale Dynamics of Southern Amazonian Rain Forests. *Science* vol. 290, pp. 2291-2294.

Miall, A.D., 1992. Alluvial Models. In: Walker, R.G. & James, N.P. (Eds.) *Facies Models - Response to sea-level change*. Geological Association of Canada, Newfoundland, pp 119-142.

Pessenda, L.C.R., Gouveia, S.E.M., Aravena, R., Gomes, B.M., Boulet, R., Ribeiro, A.S., 1998. 14C dating and stable carbon isotopes of soil organic matter in forest-savanna boundary areas in southern Brazilian Amazon region. Radiocarbon 40, 1013-1022.

Pessenda, L.C.R., Gouveia, S.E.M., Aravena, R., Boulet, R. & Valencia, E.P.E., 2004. Holocene fire and vegetation changes in southeastern Brazil as deduced from fossil charcoal and soil carbon isotopes. *Quaternary International* vol. 114, pp. 35-43.

Rossetti, D.F. & Truckenbrodt, W., 1997. Revisão estratigráfica para os depósitos do Albiano-Terciário Inferior (?) na Bacia de São Luís, Maranhão. *Boletim do Museu Paraense Emílio Goeldi* vol. 9, pp. 29-41.