CLIMATIC AND HYDROLOGICAL CHANGES ON TIDAL FLATS NEAR THE MOUTH OF AMAZON RIVER DURING THE HOLOCENE

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Keywords: Amazonia, Facies analysis, Palynology, C and N isotopes, Climate changes

1. INTRODUCTION

Several studies indicate that Amazon climate has varied during the Holocene with significant fluctuations in precipitation (e.g. Desjardins et al, 1996; Pessenda et al, 2004), and possibly, in the river water discharge such as Amazon River and its tributaries (e.g. Maslin & Burns 2000). In Amapá littoral, extensive tidal flat deposits, developed adjacent to the Amazon River, may be more appropriate to investigate vegetation changes related to variations of the Amazon River discharge during the Holocene. However, few palaeoecological studies based only on pollen data were performed in this area (Toledo & Bush 2007; Guimarães et al, 2010). An interdisciplinary approach based on facies analysis, isotopic and pollen records may provide better information about process and environment of deposition, and the origin of organic matter preserved in coastal deposits, respectively. Therefore, an interproxy study based on sedimentary facies, pollen, spores, δ13C, δ15N, C/N and radiocarbon dates was applied in order to investigate the sedimentary process, vegetation changes and sources of organic matter accumulated on tidal flats near the mouth of Amazon River during the mid and late-Holocene.

2. MATERIALS AND METHODS

The regional geology includes Mesoarchean-Devonian Crystaline and Metassedimentary rocks to western part, and Pleistocene sandstone and conglomerates in the eastern part interpreted as tidal depositional systems (Souza & Pinheiro 2009). Along the coastal plain adjacent to the Amazon River, extensive north-south trending Holocene terraces composed of sand and mud have developed along the coastal plain adjacent to the Amazon River. The modern vegetation of Macapá region is represented by periodically inundated herbaceous-shrubs field (upland to supratidal zone) and permanently inundated herbaceous field

(supratidal zone). The intertidal flat is colonized by well-developed "várzea" (flooded freshwater forests). The vegetation of Amapá region is characterized by well-developed mangrove forests, herbs vegetation and "várzea" (supra and intertidal flat). The sediment cores were sampled from the city of Macapá (freshwater influence), and the city of Amapá (brackish water influence) using a Russian Sampler. Facies analysis included descriptions of color, lithology, texture and structures. X-ray radiographs aided the identification of sedimentary structures. 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. Five bulk samples of ~ 2g each were were analyzed by Accelerator Mass Spectrometry (AMS) at the Center for Applied Isotope Studies (Athens, Georgia, USA).

3. RESULTS AND DISCUSSION

The sediment cores consist mostly of bioturbated mud and sand, heterolithic deposits, coarse to fine sands with cross-lamination and massive sand. These lithologies are partially organized into fining upward cycle and rhythms. Pollen and spore records, $\delta^{13}C$, $\delta^{15}N$ and C/N values were added to facies characteristics in order to define four facies associations that represent typical tidal flat settings (mangrove/mixed flat, tidal sand flat, small-scale point bar and "várzea/transitional vegetation). The data suggest mangrove predominance and the accumulation of brackish water organic matter over a tidal mud flat from Macapá littoral around 5560 - 5470 cal yr BP. Between 5560 - 5470 and 5290 - 5150 cal yr BP, the data suggests retraction of mangrove and expansion of Arecaceae and herbaceous vegetation followed by an increase in the contribution of freshwater organic matter (Figure 1). The point bar sequence found in the Macapá site reveals a common reworking process of the tidal flat through the lateral migration of a meandering creek, with later development of transitional vegetation under freshwater influence. Following the natural vegetation succession under relatively stable climate and hydrological conditions, the expansion of "várzea" forests occurred since 600 - 560 cal yr BP until the present. Regarding the littoral of the town of Amapá (150 km away from the mouth of the Amazon River), the mangrove forests have colonized tidal mud flats during the last 2350 - 2300 cal yr BP. However, the *Acrostichum* sp. (mangrove ferns) has expanded over the last ~1500 cal yr BP. This fern tends to invade open areas under relatively less salty water and high rainfall conditions (Medina et al, 1990). Furthermore, the current distribution of freshwater vegetation near the town of Amapá suggests a continuous colonization of "várzea" vegetation to the detriment of mangrove during the late Holocene (Figure 1).

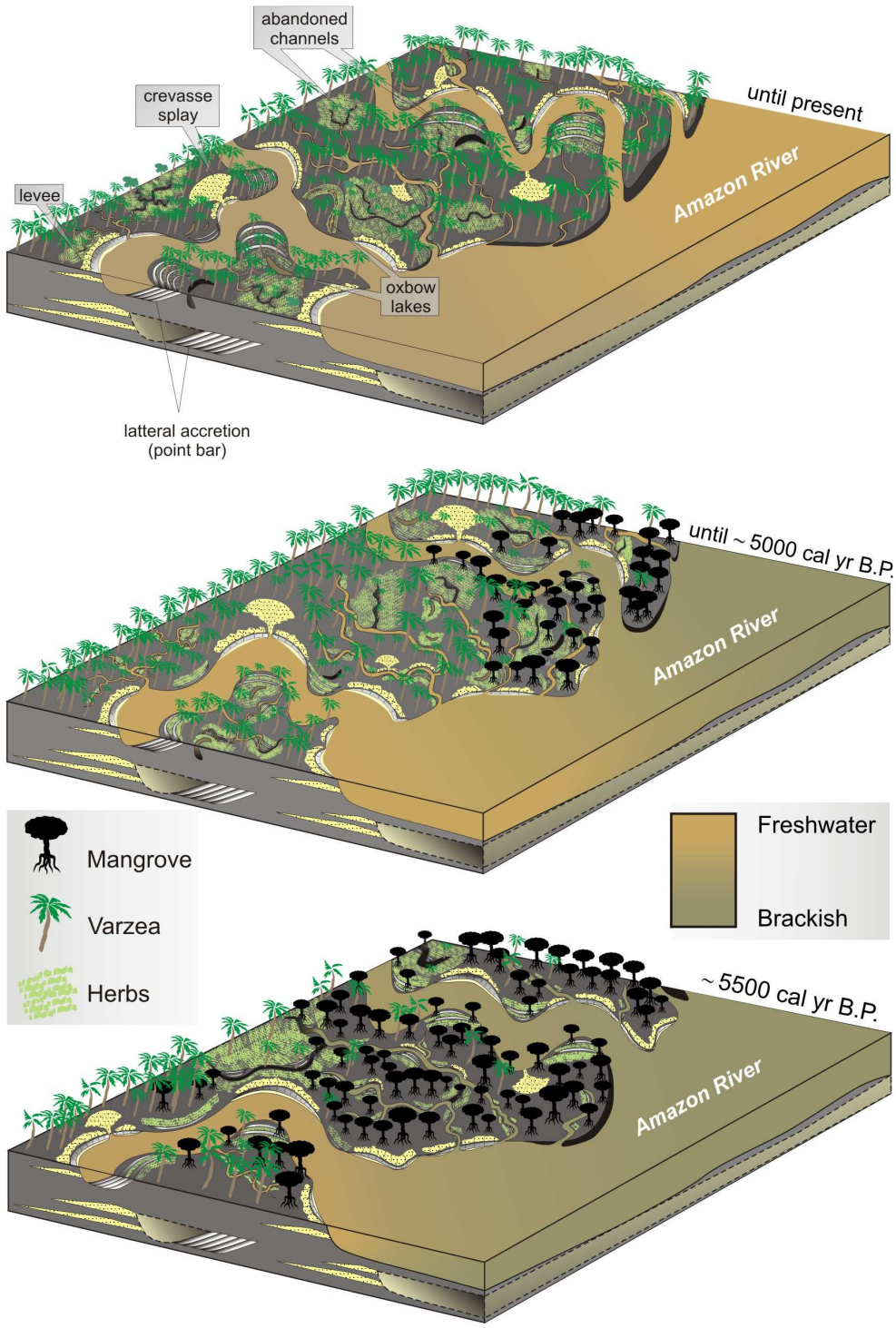

Figure 1: Schematic representation of successive phases of sediment accumulation and vegetation change in the study area according to Amazon River inflow in a stationary littoral.

Despite of this work is restricted to data on palaeovegetation changes and organic matter sources, we consider it appropriate to propose a hypothesis to explain this environmental alteration through palaeoclimate changes affecting the Amazon River inflow during the Holocene. Thus, after the post-glacial sea-level rise, the relative sea-level along the Northern Brazilian littoral reached the current sea-level between 7000-5000 yr BP, and did not show significant oscillations during the last 5000 years (Cohen et al, 2005). However, our data show that after the sea-level rise an increase in fluvial influence occurred along the study site. Recently, the Amazon River discharge has a great influence on tidal flats, limiting the mangrove vegetation to the northwestern Amapá littoral (Guimarães et al, 2010). Therefore our hypothesis is that during the mid-Holocene the Amazon River inflow was lower than today, which allowed an increase of marine influence Macapá site Afterward, the retraction of mangrove and expansion of freshwater vegetation indicates the return of more humid climate conditions and rise of Amazon River inflow. Along the littoral of the town of Amapá, at least during the last 2350 - 2300 cal yr BP, the marine influence allowed the maintenance of mangrove vegetation and the increase in Amazon River inflow during the late Holocene was not strong enough to result in the total replacement of mangrove by “várzea” and/or inundated field, such as occurred on the Macapá site after 5290 - 5150 cal yr BP (Figure 1).

4. Conclusion

The tidal flat data analyzed indicate significant vegetation changes. The marine influence and resultant mangrove expansion occurred between 5560 - 5470 cal yr BP and ~5430 cal yr BP. Between ~5430 and 5290-5150 cal yr BP, the mangrove retreated and freshwater vegetation expanded, which suggests a decrease of marine influence. During the last 3000 years, freshwater vegetation developed along the tidal flat from Macapá site. However, on the northwestern Amapá littoral, which lies 150 km away from the mouth of Amazon River, the mangrove forests have colonized part of the tidal mud flats during the last 2350 - 2300 cal yr BP. This suggests that marine influence allowed the maintenance of this vegetation, and the increase in fluvial inflow did not result in a complete replacement of mangrove by freshwater vegetation.

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