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Hydrological changes in west Amazonia over the past 6 ka inferred from geochemical proxies in the sediment record of a floodplain lake

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Abstract

The Amazon is responsible for the higher discharge of water and sediment from continent to ocean in the world, but the Amazon basin embodies a large variety of regions with different seasonal climate, hydrological regimes and vegetation. Some of these compartments may be considered as the most critical zones because they encompass severe changes in the recent past and one of the geomorphological features mostly impacted by these changes are the Amazon floodplains. In this study we report data from a floodplain lake, Quistococha, in Peru. The sediment was dated, radiographed, described and bulk density, granulometry, mineral composition, and total organic carbon were determined. Two distinctive sedimentary depositional phases were identified. During the first one, between 6100 and 5600 cal years BP, Quistococha Lake was strongly influenced by the Amazon River constraining high sediment accumulation rates. The influence of Amazon River decreased and ceased around 5600 cal years BP, due to an avulsion of the River toward its present-day position. Between 5600 and 2600 cal years BP a gap in sedimentation is observed, probably related to the dry mid-Holocene climate conditions. The sedimentation re-started about 2600 cal years BP, now the lake is an isolated lake.

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1. Introduction

The Amazon Basin covers more than one third of the South American continent, and its discharge contributes almost one fifth of the total discharge of all rivers of the world. Due to the flat topography, the high rainfall, and the pronounced seasonality of precipitation, large areas of the Amazon Basin are periodically flooded during rainy seasons. The flooded areas cover 44 % of the entire Amazon Basin and comprise one of the largest wetlands in the world [1]. Sedimentation processes in Amazon floodplain lakes are strongly dependent of the hydrology of the River. The aim of this study was to reconstruct the Amazon paleohydrological changes that controlled sedimentation processes in the Quistococha Lake, an Amazonian floodplain lake.

2. Study area and methods

Quistococha Lake is located near the Peruvian city of Iquitos in the western part of the Amazon Basin. The lake (3°49’46.87S/ 73°19’05.67W) is situated between a 15 m high terrace forming the western margin of the recent Amazon floodplain, and the River Itaya draining the alluvial plain to Iquitos (Figure 1). One sediment core (QUI 1), 290 cm-long, was analyzed for this study. The core was dated with ^{14}C Accelerator Mass Spectrometry (AMS, LMC14, France), radiographed (SCOPIX), described and bulk density, granulometry (laser particle analyzer), mineral composition (XRF and DRX), and total organic carbon (TOC) were determined.

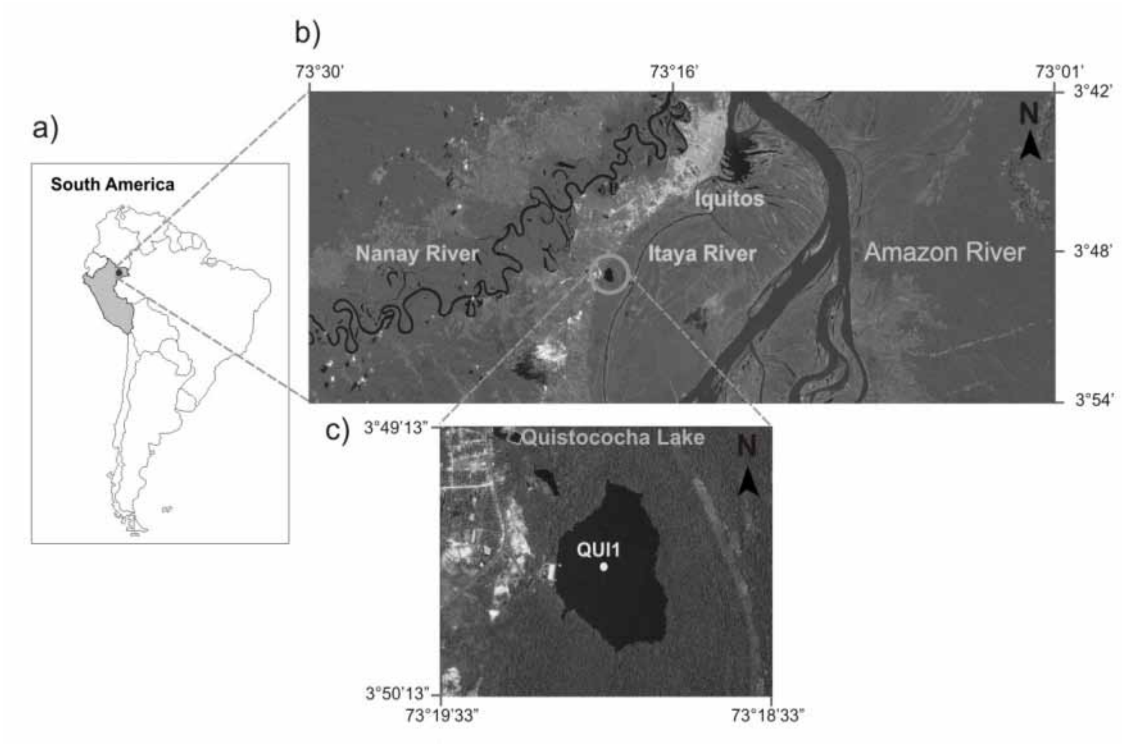

Figure 1: Location of Quistococha Lake in the Peruvian Amazonia and the QUI1 core site.

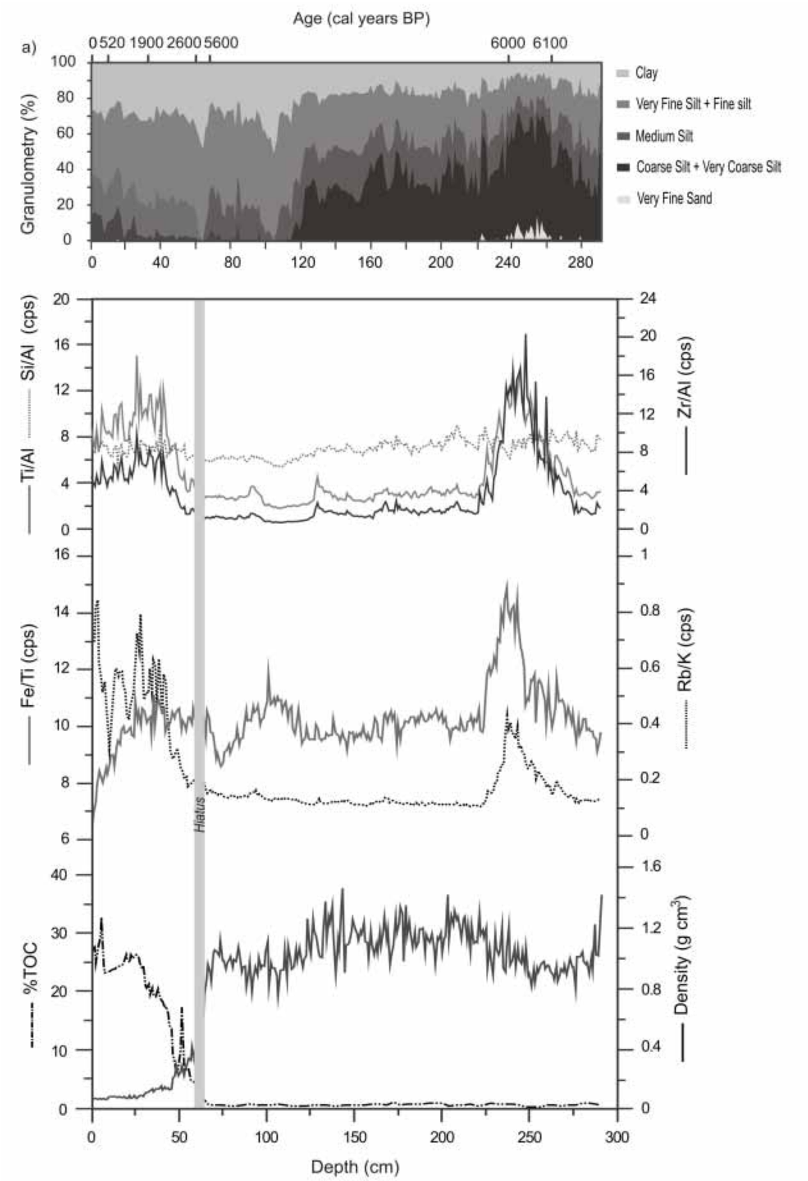

Figure 2: Grain size fractions; XRF data : Si/Al, Ti/Al and Zr/Al ratios; Fe/Ti and Rb/K ratios; total organic carbon (TOC contents) and density (g cm^{-3}).

3. Results and discussion

In order to interpret the role of paleohydrological changes on Quistococha Lake sedimentation, we adopt an integrated approach measuring density, particle size, total organic matter (TOC), X-ray diffraction (XRD) and X-ray fluorescence (XRF). There are marked differences along the core (Figure 2). All parameters point out two distinct lacustrine environments during the last 6100 cal years BP.

The first, corresponding to the unit 2 (6100-5600 cal years BP), is characterized by high density (0.6 and 1.5 g cm^{-3}), coarser fractions (very fine sand + coarse silt), high sedimentation rates (0.5 cm yr^{-1}), low TOC (0.2 and 1.8 %), characterizing a system under high river influence (Figure 2). The TOC contents (mean 0.5 %) found in this unit are in the same range from those proposed for the particulate organic carbon (POC) transported by the Amazon River [2,3]. For the mineral fraction, the Rb/K and Fe/Ti ratios, show good correlations (r^2= 0.70) (Figure 2).

However, high Rb/K ratio, between 6100 and 6000 cal years BP, indicates the input of chemically weathered material to the lake and the ratio Fe/Ti indicates that this material has a pedogenetic source. This material is related to the coarser fraction and the clay mineralogy indicates a higher proportion of kaolinite relative to illite. This is probably due to an episode of intense erosion in the local watershed of the lake.

Between 6000 and 5600 cal years BP, a decrease in Rb/K ratio and coarser fractions, shows the input of chemically unaltered material (Figure 2), accompanied by a slight increase in the proportion of illite in relation to kaolinite. A good correlation between Ti and Fe (r^2=0.91), suggests that these elements share a common source. Iron is prone to diagenetic remobilization, however the good correlation with Ti (which is inert to diagenetic processes), and the similarity of their records imply that the sediments were not affected by diagenetic processes [4,5]. The abundance of zirconium and quartz can be determined by Zr/Al and Si/Al ratios, but the Si/Al ratio did not show significant variations. This may indicate that the Si deposited not only comprises quartz, but mainly aluminosilicates. The Zr and Ti elements are usually concentrated in the heavy mineral fraction and Zr/Al and Ti/Al ratios appear to have good correlation with the coarse fractions (Figure 2). During this period the Amazon River, carrying almost unaltered sediments from the Andes, is probably the main source of sediment supply to the lake.

A gap in the record between about 5600 and 2600 cal years BP corresponds to a break in sedimentation during the dry Mid Holocene. This process probably due to an avulsion of the main stem induced significant changes in the lacustrine sedimentation.

The second lacustrine environment, starting at about 2600 cal years BP, represents the unit 1, and was formed after the sedimentation hiathus. This lacustrine environment is characterized, in contrast to unit 2, by low density (0.1 and 0.6 g cm^{-3}), low sedimentation rates (0.02 cm yr^{-1}), finer particles, high organic contents where the TOC varied between 10 and 40 % (Figure 2). A significant increase in Rb/K ratio in this unit is consistent with a greater proportion of clay in the sediment [6] (Figure 2). The amplitudes of Rb/K and Fe/Ti ratios, indicate input of chemically weathered terrigenous material from the lake watershed. The clay mineralogy indicated the lowest percentages of illite in unit 1, while the percentage of kaolinite was the largest of the core.

4. Conclusions

The hydrological changes observed in the Quistococha Lake indicate two periods of sedimentation during the last 6100 cal years BP. Between 6100 and 5600 cal years BP, the lake was strongly influenced by the Amazon River which maintained high sedimentation rates. XRF analyses show a noticeable interval of lake watershed erosion between 6100 and 6000 cal years BP. The influence of Amazon River decreased and ceased around 5600 cal years BP, due to an avulsion of the River toward its present-day position. Between 5600 and 2600 cal years BP a gap in sedimentation is observed, probably related to the drier Holocene climate conditions. The sedimentation re-started about 2600 cal years BP but now the lake is an isolated lake, far from the Amazon influence where the main input of material comes from the weathered soils of the lake watershed.

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