FOREBULGE EVOLUTION: THE CASE STUDY OF THE ARCH OF IQUITOS (PERU)

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INTRODUCTION

The modern foreland basin system adjacent to the Andes is considered the type example of retroarc foreland basin (Horton and DeCelles, 1997). In the Central Andes, these authors have defined a four components foreland basin system (i.e. the wedgetop, the foredeep, the forebulge and the backbulge depozones). This system is elongated parallel to the orogenic wedge, which propagated eastward since the late Cretaceous-Paleocene. According to latest studies (Gil, 2001; Hermoza et al., 2002), a continuous orogenic loading was not the rule in the Amazonian foreland basin system.

The Amazonian basin contains actually the world's largest fluvial basin (actual drainage area of 5.8×10^6 km^2, depositional area of approximately 2.5-3×10^6 km^2). The Amazonian basin encompasses several Cenozoic sub-basins delimited by structural/geomorphological arches. From West to East, the Amazon runs across (figure 1): i) the Marañón foreland basin, ii) The Solimoes (intracratonic basin, Caputo, 1991) basin limited to the East by the Purus Arch and to the West by the Iquitos Arch (Caputo, 1991) and divided into two sub-basins separated by the Carauari Arch and iii) the Amazonas basin (Paleozoic intracratonic basin) limited to the East by the Gurupua Arch and to the West by the Purus Arch.

The Marañón basin started to develop in the Late Cretaceous-Paleocene. During this period, it constituted probably the backbulge depozone of a foreland basin system (Gil, 2001). From Eocene to Oligocene, the development of the Andean foreland basin system was controlled by the decrease of tectonic loading (orogenic unloading, Christophoul et al., 2002). From Upper Oligocene to Middle Miocene, the Marañón basin constituted the foredeep depozone of the Andean foreland basin system as a result of orogenic loading context (Gil, 2001). From Middle Miocene to Upper Miocene, Gil (2001) recognizes in the Marañón basin an orogenic unloading episode with well constrained foresag depozone, which would be filled up by the Pebas Formation. The origin of the Pebas Fm has been widely discussed. According to latest studies (see for example Räsänen et al., 1995), the Pebas Fm consists of tidal deposits, which set up in a shallow marine environment (i.e. the "Pebasian Sea"). The origin of the Pebasian Sea, which extended toward the Purus Arch, is generally correlated and ascribed to the latest Serravallian rise of the global sea level ~ 10 Ma. Contrary to these authors, we impute the presence of the Pebasian Sea to the Middle Miocene-Upper Miocene unloading episode. Based on sedimentation accumulation rate, Hermoza et al., (2002) confirm this Middle Miocene orogenic unloading episode and propose that the foreland basin system has then evolved continuously from Upper Miocene to Pleistocene with a foredeep type sequences that migrates progressively to the East. This latter author has shown that the sedimentation accumulation rate increased strongly during the Upper Miocene-Pleistocene period. From this short literature review of the evolution of the Marañón foreland basin since Paleogene, the Geodynamic evolution of the Peruvian Andes as recorded in the dynamic of the Marañón foreland basin system set out, at least, a 4 steps evolution: i) orogenic loading during the Paleocene; ii) orogenic unloading from Eocene to Oligocene; iii) orogenic loading from Upper Oligocene to Middle Miocene; and iv) orogenic unloading from Middle Miocene to Upper Miocene.

The aim of this paper is to investigate the evolution of the Marañón foreland basin system from Upper Miocene to actual times with emphasis on the evolution of the forebulge depozone.

RESULTS

We have investigated the region of Iquitos (Loreto, Peru; Figure 1). Geomorphologically, this region presents two domains: the non floodable terrains known as the "tierra firme" (about 150 m above sea level) and the Quaternary floodable alluviums plains (100 m above sea level). The "tierra firme" terrains constitute the main part of the Iquitos Arch. The Iquitos Arch is trending NW-SE parallel to the Andean chain and is from 140m abs to 200m abs. It has more than 1000 km long and between 100 and 150 km wide. It is situated at more than 400 km from the orogenic front. From numerical modeling and gravimetrical map (Sanchez et al., 1999), the Iquitos Arch is inferred to correspond to the forebulge of the Marañón foreland basin system.

A 100 km long cross sections has been set out perpendicularly to the axe of the Iquitos Arch (along the Nauta-Iquitos road). Two representative sedimentological logs (IQ35 and IQ40, see Figure 2) have been selected to set up the sedimentology of the Iquitos Arch.

The section IQ 40 is marked by four sequences of tidal-like deposit separated from each other by transgressive surfaces. The four transgressive surfaces dip to the East. These tidal deposits, which present paleocurrent direction to the SW, are succeeded by a fluvial formation with paleocurrent to the NE. From the base to the top, this formation consists of facies Sp, Fsh, Sh, Gh, Sh and Gh. The section IQ 35 displays an erosive contact between the mud/clay sediments of the Pebas Fm and the white sand of the "Iquitos formation".

From this two representative logs, the facies succession displays the competition between uplift and quiescence stages of the forebulge. Uplift stages are marked by prograding stacking pattern from shallow water to embouchure environments while quiescent stages are recorded by the transgressive stacking pattern of tide-influenced units. The sedimentary succession is slumped affected by syn-sedimentary normal faults. Such soft-sediment deformation bear witness to tectonic activity. This movement of the substratum of the forebulge depozone can be ascribed to reactivation of Proterozoic normal basement-faults well-imaged on seismic section. The Iquitos Arch is still tectonically active since normal faults affect Holocene fluvial deposit (our study and Dumont et al., 1988 in the southern part of the Arch). This indicates that the forebulge is still growing.

CONCLUSIONS

This study has showed that i) the Arch of Iquitos corresponded to the forebulge of the Marañón foreland basin system, ii) the uplift of the forebulge was recorded in the sedimentation by marine facies grading upward to estuary-like facies and to actual fluvial system with shifting in the orientation of the drainage network, and iii) the uplift of the forebulge is still active and associated to neo-tectonic activity ascribed to the reactivation of Proterozoic normal fault. From these results, it appears that the Marañón foreland basin system is controlled by increase in tectonic loading since Upper Miocene. This increase has caused the emergence of the Iquitos forebulge, which have probably induced the retreat of the Pebasian sea and modified the drainage network. The emergence of the forebulge is not as continuous as expected (i.e. transgressive surfaces). The area comprised between the Iquitos Arch and the Carauari Arch is expected to be the backbulge depozone of the Marañón foreland basin system since at least the Upper Miocene.

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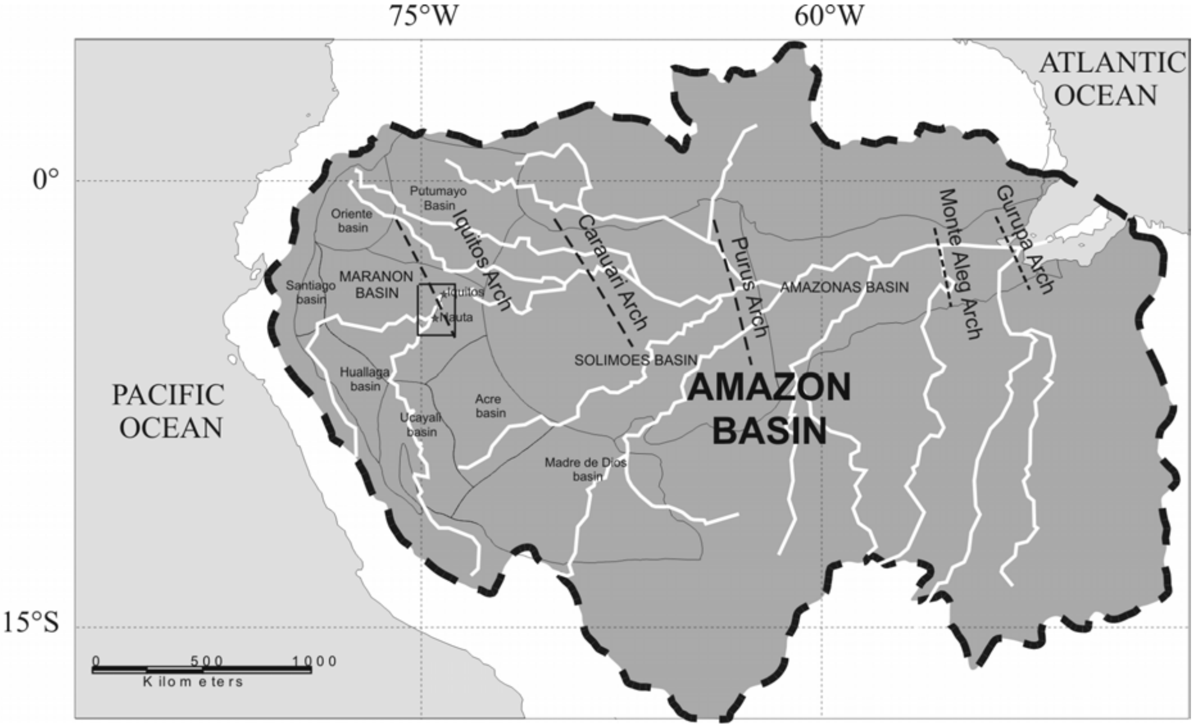

Figure 1: Map of the actual Amazon Basin The dark grey set delimited by sharp dashed lines represents the actual Amazon basin. Rivers are in white, solid lines indicate the limit of the basins. Axes of the Amazon arches are in dashed lines. The rectangle delineates the studied area.

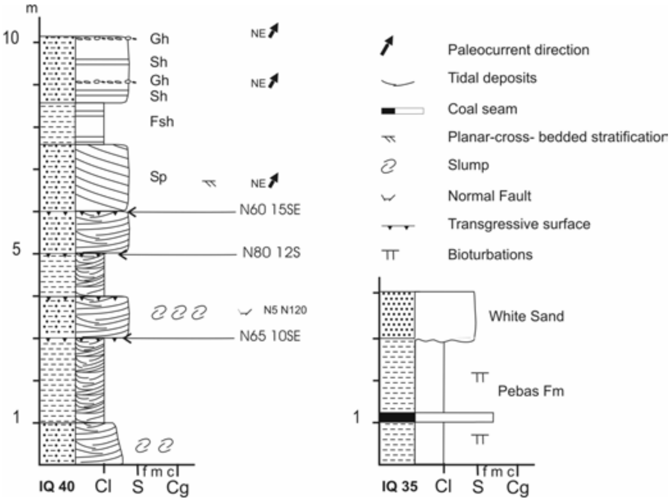

Figure 2: The two representative sedimentary logs. Strike and dip of the transgressive surfaces and faults are given.