

FORELAND BASIN SYSTEM EVOLUTION OF THE PERUVIAN ANDES: NEW INSIGHTS FROM MASS BALANCE COMPUTATION

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INTRODUCTION

The Huallaga-Marañón basins are part of the NE Subandean basins of the Peruvian Andes (Fig. 1). The Huallaga basin, which is deformed by thrust-and-fold structures, represents the Subandean zone s.s. (wedge-top depozone), whereas the poorly deformed Marañón basin corresponds to the actual foredeep depozone. Wells, seismic sections and surface data of the Marañón and Huallaga basins permit to calculate the masses of sediments accumulated since the Eocene. The mass balance computations are performed using the method developed by Métivier & Gaudemer (1997), and modified by Deniaud (2000). The results of this study coupled with sedimentary and structural data allow us to reconstruct the evolution of the northern Peruvian foreland basin system from the Eocene to the Present.

GEOLOGICAL AND STRUCTURAL SETTING

The development of the eastern Andean foreland basin system started at the Late Cretaceous times in a marine environment (Barragan, 1999). The Huallaga and Marañón Subandean basins are individualized since Eocene times. They propagated eastward during the deposition of mainly continental series. In this study, we consider exclusively the Huallaga- Marañón stage of the foreland basin evolution.

In the Huallaga Basin (Fig. 2), the Eocene to Pliocene series corresponds to a prograding sequence evolving from estuarine facies to deltaic and continental facies. Reflection seismic data show that the upper part of this succession is characterized by progressive unconformities displaying the occurrence of thrust-related folding. In the Marañón basin, wells and seismic data show that the Eocene to Pliocene sedimentary fill comprises two sequences (Fig 2). The 1st sequence (Middle Eocene to Middle Miocene) developed above an erosive surface and started with the conglomerates (Lower Pozo Fm). This conglomerates have been interpreted as a consequence of orogenic unloading (Christophoul et al., 2002; Gil, 2001). Above this conglomerates, marine argillaceous sediments have been deposited (Upper Pozo or Orteguzza Fm. of the Oriente basin) from Middle Eocene to Lower Oligocene (biostratigraphic age ROBERTSON RESEARCH, 1990). In the Oriente basin, the lateral equivalent of the Lower Pozo conglomerate have been dated (Upper Tiyuyacu Fm 46.0±0.4 My, Christophoul et

al., 2002). The Sequence II (Upper Miocene-Pleistocene) displays a coarsening and thickening upward pattern. The basal part consists of green clays and red-grey limestones indicating a shallow marine environment, which gradually passes to continental (Fm. Pebas: Gabb, 1969; Sanchez & Romero, 2000). According to palynologic dating, the deposition occurred between the Middle Miocene and the Late Miocene (16,3-10,4 My) (Hoorn M, 1993; Sanchez & Romero, 2000).

The Huallaga and Marañón basins present different styles of deformation. The Huallaga basin or Subandean zone is deformed by thrusting, tectonic inversions and halokinesis (Baby, 1995). The Marañón basin is only affected by slight tectonic inversions of pre-Cretaceous grabens (Baby et al., 1999; Gil et al., 2000; Gil 2001).

MASS BALANCE COMPUTATION

The mass of sediments deposited since Eocene times in the Huallaga and Marañón basins is determined using isopach maps obtained from the interpretation of seismic sections, and applying the Métivier 's formula in each of its points (petroleum wells or virtual wells deduced from the seismic). The average accumulation rates are determined for Sequence I (Middle Eocene to Middle Miocene) and Sequence II (Upper Miocene to Pleistocene). In the Huallaga basin, the highest accumulation rates ($30 \cdot 10^7$ t/My/m²) are registered during the Middle Eocene. These rates decrease during the Upper Miocene and Pleistocene times ($10 \cdot 10^7$ t/ My/m²). These calculations show general decrease of the average mass accumulation rates during the Neogene (Fig. 3). In the Marañón basin, lowest accumulation rates are registered from Middle Eocene to Middle Miocene (Fig. 3), i.e. during the deposition of the Sequence I ($25 \cdot 10^7$ t/My/m²). During the Upper Miocene and Pliocene (Sequence II), accumulation rates considerably increase and reach $110 \cdot 10^7$ t/My/m². The tectonic-sedimentary evolution of the Marañón basin is then marked by a general increase of the Neogene accumulation rates, which is the contrary to the Huallaga basin evolution.

DISCUSSION AND CONCLUSION

The Eocene-Neogene geodynamic evolution of the Peruvian Andes was recorded by two sedimentary sequences deposited in the Subandean basins. Each sequence shows an evolution of the dynamic subsidence, where the tectonic loading increases progressively.

In the Sequence I (Eocene-Middle Miocene), during the Eocene–Lower Oligocene, the Huallaga-Marañón foreland basin system experienced orogenic unloading. The marine sediments of the Lower Pozo Fm. have been deposited in a foresag depozone (*sensu* Catuneanu et al. 2000). From the Lower Oligocene to the Middle Miocene, the Marañón basin was gradually filled up by a prograding sequence. At the same period, the Huallaga basin experienced an estuarine to continental sedimentation with high accumulation rates characterizing a foredeep depozone. In the Marañón basin, the sediments accumulation rates are lower. Such small rates can be interpreted as the result of backbulge subsidence. This backbulge can be located east of the Contaya Arch.

During Upper Miocene times (base of the Sequence II), the Subandean basins are controlled by orogenic unloading, which allowed a marine transgression to reach these basins. The deposition of the Pebas Fm. occurs in near shore environments (tidal facies in the Marañón basin and deltaic facies in the Huallaga basin). After this marine incursion, the foreland basin system is again controlled by tectonic loading. As a result, the Huallaga

basin is affected by thrust-tectonics as shown by the development of growth strata overlying Miocene deposits. Sedimentation accumulation rates indicate a lower subsidence corresponding to the flexural subsidence minus the thrust related uplift. In the same period, the Marañón basin transformed in foredeep depozone with a sharp increase of the accumulation rates.

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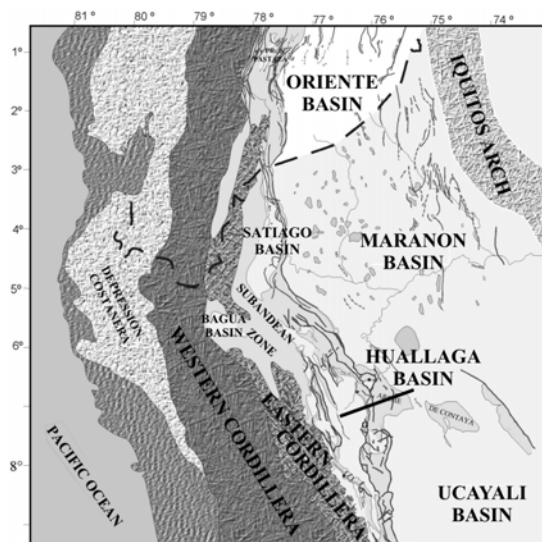


Fig. 1: Sketch map showing the Andean Foreland Basin System of Northern Peru.

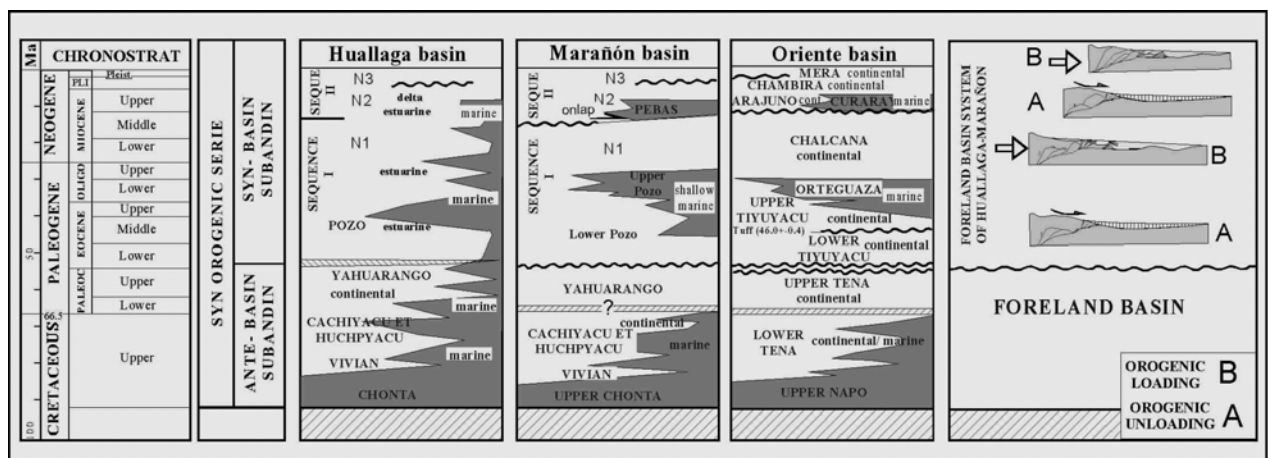


Fig. 2: Stratigraphic correlation chart between different basins in Northern Peru

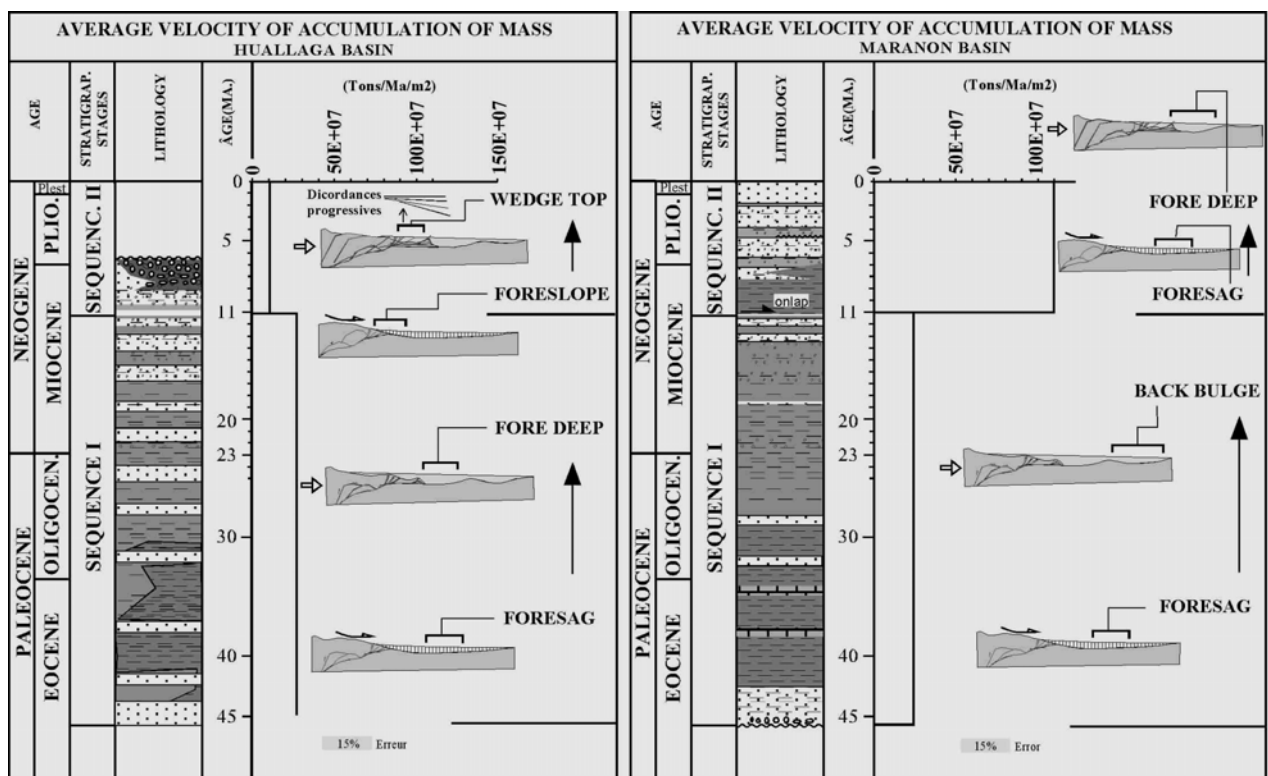


Fig. 3: Geodynamic and sedimentary accumulation rates evolution during Eocene to Pleistocene.