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

Wilber HERMOZA(1), Patrice BABY(2), Stéphane BRUSSET(3), Frederic CHRISTOPHOUL(4), Wily GIl(5)

(1) IRD UR 104 LMTG-UMR 5563, 38 rue des 36 Ponts 31400 Toulouse-France ; hermoza@lmtg.ups-tlse.fr
(2) IRD UR 104 LMTG-UMR 5563, 38 rue des 36 Ponts 31400 Toulouse-France ; baby@cict.fr;
(3) IRD UR 104 LMTG-UMR 5563, 38 rue des 36 Ponts 31400 Toulouse-France ; brusset@cict.fr
(4) LMTG-UMR 5563, 38 rue des 36 Ponts 31400 Toulouse-France ; christop@cict.fr;
(5) LMTG-UMR 5563, 38 rue des 36 Ponts 31400 Toulouse-France ; wf_gilrodriguez@hotmail.com

KEY WORDS: Foreland Basin, Geodynamic, Mass balance, Huallaga, Marañón, Peruvian Andes.

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 (Chistophoul et al., 2002; Gil, 2001). Above this conglomerates, marine argillaceous sediments have been deposited (Upper Pozo or Orteguaza 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, Chistophoul 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 (30.10^7 t/My/m^2) are registered during the Middle Eocene. These rates decrease during the Upper Miocene and Pleistocene times (10.10^7 t/ My/m^2). 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 (25.10^7 t/My/m2). During the Upper Miocene and Pliocene (Sequence II), accumulation rates considerably increase and reach 110.10^7 t/My/m^2. 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.

ACKNOWLEDGEMENTS : Research supported by INSU grant 99PNSE59 and IRD (Tectonique, érosion et sédimentation dans le bassin de l'Amazone : du Mio-Pliocène à l'Actuel).

REFERENCES

Baby P. 1995. Informe final convénio ORSTOM-PETROPERU, Rapport inédit, 15.

Baby P., Rivadeneira M., Christophoul F., Barragan R. 1999. Style and timing of deformation in the Oriente Basin of Ecuador, 4nd International Symposium on Andean Geodynamics (ISAG'99), Univ. Göttingen (Germany), Extended Abstracts Volume, 68-72.

Barragan R. 1999. Relations entre volcanisme, tectonique d'inversion et sédimentation dans le Bassin Crétacé équatorien Oriente. Thèse Université Paul Sabatier de Toulouse. 223 pp.

Catuneanu O. Sweet A. R. & Miall A. D. 2000. Reciprocal stratigraphy of the Campanian – Paleocene Western Interior of North America. Sedimentary Geology, 134, pp. 235-255.

Chistophoul F. Baby P. & Davila C. 2002. Stratigraphic responses to a major tectonic event in a foreland basin : the Ecuadorian Oriente Basin from Eocene to Oligocene times. Tectonophysics 345, pp. 281-298.

Deniaud Y. 2000. Enregistrements sédimentaire et structural de l'évolution géodynamique des Andes Equatoriennes au cours du Néogène: étude des bassin d'avant arc et bilans de masse. Géologie Alpine, 200, Mémoire Hors Série 32. Université Joseph Fourier, Grenoble, 157.

Gabb W. M. 1869. Descriptions of fossils from the clay deposits of the Upper Amazon. American Journal of Conchyology, 4, 197-200.

Gil W. 2001. Evolution latérale de la déformation d'un front orogénique: Exemple des bassins subandins entre 0° et 16°S. Thèse de doctorat de l'Université Paul Sabatier Toulouse III, 150.

Gil W., Baby P. & Rivadeneira M. 2000. Estilo tectónico e histórico de la deformación de las cuencas Marañón y Oriente. Ximo Congreso Peruano de Geología. Lima, 4.

Hoorn M. C. 1993. Geología del Nororiente de la Amazonia Peruana : La Formación Pebas. En : Amazonía Peruana-Vegetación humeda tropical en el llano subandino. Proyecto Amazonia Universidad de Turku (PAUT) y ONERN, Jyväskylä, 69-85.

Métivier F., Gaudemer Y. 1997. Mass transfer between eastern Tien Shan and adjacent basins : Constraints on regional tectonics and topography. Geophysical Journal International, 128, 1-18.

ROBERTSON RESEARCH 1990. Palynological zonation. Inf. inédito Petroperu Robertson Research.

Sanchez A. et Romero D. 2000. Sedimentologia y paleogeografía de la Formacion Pebas (Mioceno medio a Superior), del nororiente peruano (región Loreto). X Congreso de Geología, Lima, 11.

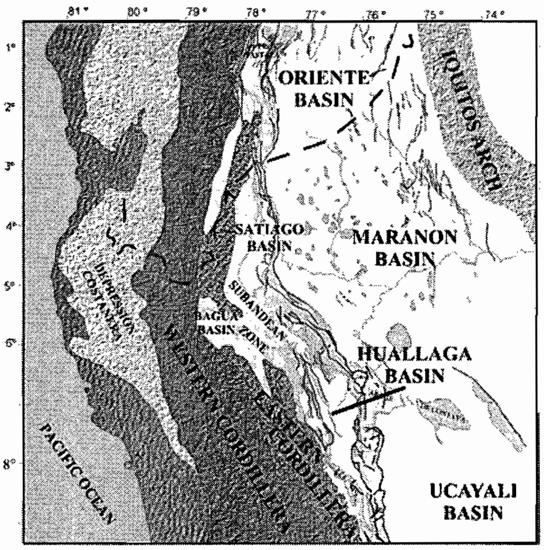

Fig. 1: Sketch map showing the Andean Foreland Basin System of Northern Peru.

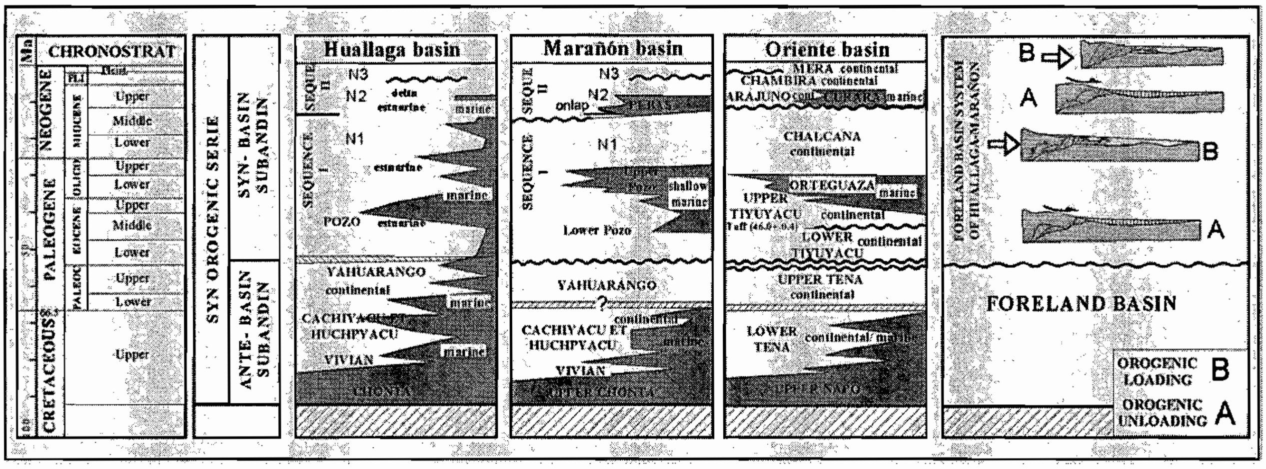

Fig. 2: Stratigraphic correlation chart between different basins in Northern Peru

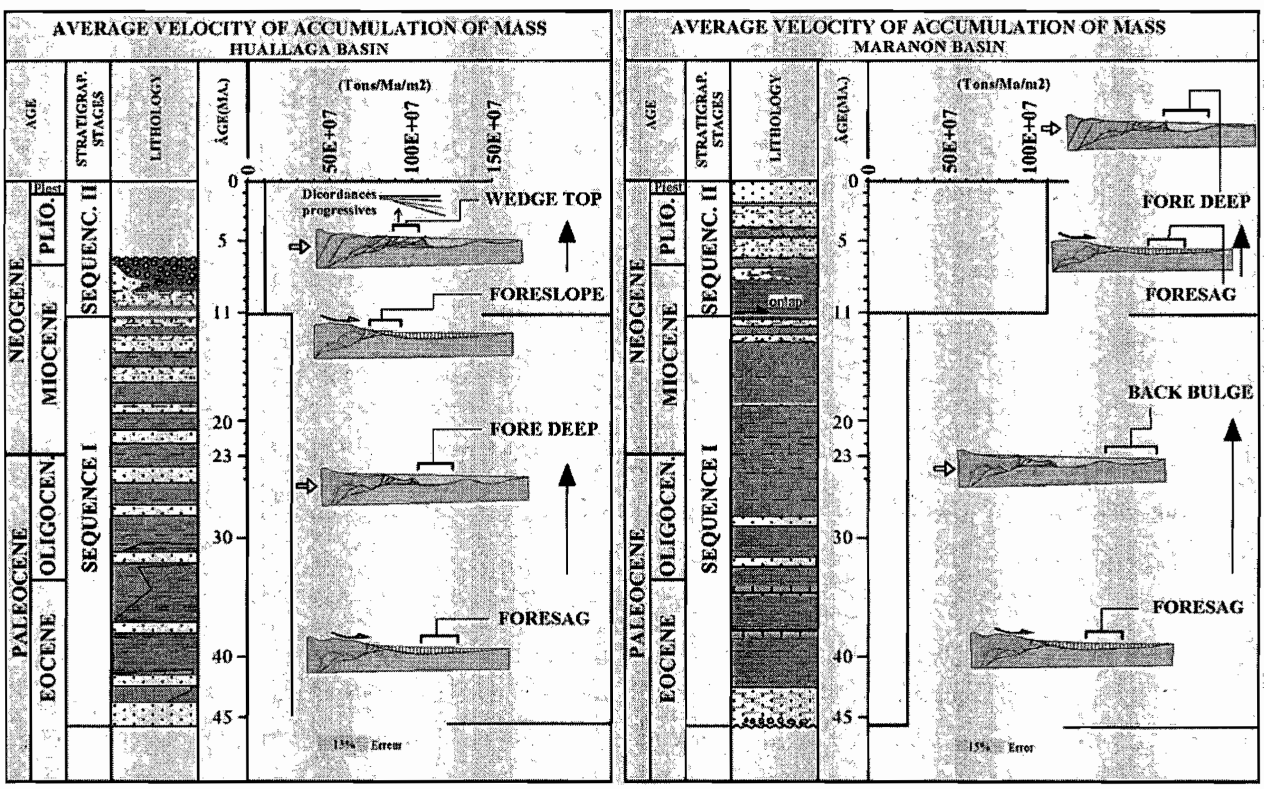

Fig. 3: Geodynamic and sedimentary accumulation rates evolution during Eocene to Pleistocene.

IRD
Institut de recherche pour le développement

UNIVERSITE PAUL SABATIER TOULOUSE III

Géodynamique andine
Andean Geodynamics
Geodinámica Andina

Résumés étendus
Extended abstracts
Resúmenes expandidos

Organisateurs | **Organizers** | **Organizadores**

Institut de recherche pour le développement
Paris

Université Paul Sabatier
Toulouse
France

2002

ISAG

IRD
Institut de recherche pour le développement

UNIVERSITE PAUL SABATIER
TOULOUSE III

GÉODYNAMIQUE ANDINE
ANDEAN GEODYNAMICS
GEODINAMICA ANDINA

5th International Symposium on Andean Geodynamics

Université Paul Sabatier, Toulouse, France,
16-18 Septembre 2002

Résumés étendus
Extended abstracts
Resúmenes ampliados

Organisateurs / Organizers / Organizadores
Institut de recherche pour le développement
Université Paul Sabatier

IRD
INSTITUT DE RECHERCHE POUR LE DÉVELOPPEMENT
Paris, 2002

COMITÉ D'ORGANISATION
COMITE ORGANIZADOR
ORGANIZING COMITTEE

P. Baby (IRD-Toulouse), J. Darrozes (Univ. Paul Sabatier-Toulouse), J. Deramond (Univ. Paul Sabatier-Toulouse), B. Dupré (CNRS-Toulouse), J.-L. Guyot (IRD-Toulouse), G. Hérail (IRD-Toulouse), E. Jaillard (IRD-Quito), A. Lavenu (IRD-Toulouse), H. Miller (Univ. München), T. Monfret (IRD-Géoscience Azur), G. Wörner (Univ. Göttingen)

Comité scientifique et représentants nationaux
Comité Científico y Representantes Nacionales
Scientific Advisory Board and National Representatives

R. Armijo (IPG, Paris), J.-P. Avouac (CEA, Paris), R. Charrier (Univ. Chile, Santiago), J.-Y. Collot (IRD, Géoscience Azur), L. Dorbath (IRD, Strasbourg), S. Flint (Univ. Liverpool), B. France-Lanord (CNRS, Nancy), L. Fontboté (Univ. Genève), Y. Gaudemer (Univ. Paris VII), R. Gaupp (Univ. Jena), F. Hervé (Univ. Chile, Santiago), T.E. Jordan (INSTOC, Cornell), J. Mojica (Univ. Bogotá), O. Oncken (Univ. Potsdam), L. Ortlieb (IRD, Bondy), R.J. Pankhurst (Brit. Antartic Surv.), V. Ramos (Univ. Buenos Aires), P. Ribstein (IRD, Paris), C. Robin (Univ. Clermont-Ferrand), S. Rosas (Univ. Lima), F. Sàbat (Univ. Barcelona), M. Schmitz (FUNVISIS, Caracas), R. Suárez Soruco (YPBF, La Paz), M. Rivadeneira (Petroproducción), W. Winkler (ETH, Zürich).

APPUIS FINANCIERS
FUNDINGS
APPOYO FINANCIERO

L'organisation de l'ISAG 2002 et les bourses accordées à un certain nombre de collègues latino-américains ont été possibles grâce au soutien financier de l'IRD (notamment de la Délégation à l'Information et à la Communication), de la région Midi-Pyrénées, de l'Université Paul Sabatier et de l'Andean Comittee de l'ILP.