The Neogene Chaco foreland basin, Bolivia: Its evolution as related to Andean tectonics

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KEYWORDS: Foreland basin system, depozone migration, Neogene, Chaco basin, Bolivia

Introduction

The up to 200 m wide Chaco foreland basin was initiated during the Late Oligocene, and evolved during the Late Miocene due to eastward migration of the deformation front as a result of active stages of crustal shortening and uplift of the adjacent Interandean and the Subandean Zone (Sempere et al., 1990; Husson and Moretti, 2002). The up to 7.5 km-thick, eastward-wedging Neogene stratigraphy is complicated by the existence of multiple basinwide unconformities with diffused relief and anticlines separated by synclines. This paper investigates the relationship of Andean thrust-belt tectonism and foreland basin system development to understanding the depositional response of the Chaco foreland basin to Andean loading and shortening using seismic and sedimentologic data set. Five isopach maps were established to determine the depositional pattern, temporal-spatial thickness distribution, and migration of the depocenter.

Stratigraphy

Five major stratigraphic units are distinguished (from base to top): (1) The up to 250m thick, easterly-sourced 27-14 Ma (Sempere et al., 1990; Marshall and Sempere, 1991) Petaca Formation unconformably overlies the eolian Late Cretaceous strata and consists of paleosol, sandstone and mudstone. The age of the basal calcretes has not been ascertained. Therefore, placing the age of the lower Petaca to be probably older than the published 27 Ma that is based on biostratigraphic dating of mammal fossils in the pebbly sandstone unit (Marshall and Sempere, 1991). The Petaca Formation was deposited in fluvial setting under arid to semi-arid conditions (Uba et al., in review). Overlying the Petaca Formation is up to 600-m-thick Yecua Formation of late Miocene age (14-7 Ma; Hulka et al., in press). The boundary between these two formations is defined by very low-angled erosional unconformity. The Yecua Formation is defined in published papers as dominantly marine facies that is not deposited in the west and south of the Subandean Zone (Marshall and Sempere, 1991; Hulka, et al., in press). However, high resolution radiometric dating of tuff within the continental facies in the Argentina's side of the Emborozu town (eastern Subandean Zone) by Echavarria, et al. (2003) documented 9.9 Ma age. This continental facies that is deposited dominantly in fluvial and lacustrine settings is till now documented in the Bolivian stratigraphy as lower part of the Tariquia Formation (Moretti, 1996). However, this continental facies is classified in this paper as correlative with the marine facies of the Yecua Formation. Therefore, is grouped under the Yecua Formation.

The up to 3800-m-thick westerly-sourced 7-6 Ma Tariquia Formation (Moretti, 1996) conformably overlies the Yecua Formation. The contact between the Yecua and Tariquia formations is gradational. The Tariquia sediments were deposited in humid anastomosing distal fluvial megafan environment (Uba, et al., in review). The 6-3.3 Ma (Moretti, 1996) Guandacay Formation. overlie the Tariquia Formation. This up to 1500-m-thick

Guandacay Formation is characterized by imbricated pebble to cobble conglomerates, sandstones, and mudstones. This formation was deposited by humid low-sinousity mid fluvial megafan (Uba, et al., in review). The cobble-dominated 3.3 Ma to Recent (Moretti, 1996) Emborozú Formation caps the foreland stratigraphic succession of the Chaco foreland basin. The Emborozu strata were deposited in perennial proximal fluvial megafan settings (Uba, et al., in review).

Discussion

The foreland basin succession is controlled by orogenic cycles of loading and unloading in response to the Andean fold- and thrust fault and climate. Five isopach maps and sedimentary facies architectures of the Neogene sequence deposited in the Chaco foreland basin show a steady change in thickness and depositional style towards the east in time. The Petaca Formation, which marks the basal foreland basin sequence consists of up to 20 m thick basal widespread calcrete, pebbly sandstone, and mudstone The well-developed paleosol indicates nondeposition or a significant time interval of low sediment accumulation rate and low subsidence. It represents backbulge depocenter, with a forebulge uplifted to the middle of the study area (ca. Villamontes-Camiri axis). This interpretation is supported by westerly paleocurrent direction. The Yecua Formation indicates increased subsidence rate (Coudert, et al., 1995) and high accommodation space in the proximal foredeep depocenter of the basin due to thrust belt loading outpacing sedimentation rate. Therefore, it defines underfilled stage of the foreland development and represents distal foredeep in the study area. The increased subsidence rate and accommodation space is attributed to onset of active Andean tectonism in the Late Miocene.

The up to 3800 m thick Tariquia Formation thickens to the west. The westerly-sourced Tariquia strata show relative low accommodation/sediment supply and indicate onset of deposition and supply of from Andean-derived sediment in the Chaco basin. The high sediment supply could be attributed to subsequent increase in denudation of during the Late Miocene uplifted rocks. It represents the sedimentation in the medial foredeep depocenter. The westerly-sourced, coarsening-upward clastics of the Guandacay Formation inidicate continuous decreased in the accommodation space. This reduction in space is attributed to flexural response to unroofing of uplifted area. The Guandacay strata represent deposition in the proximal foredeep depocenter. The progradation of proximal syntectonic wedge of the Emborozu Formation represents the progressive encroachment of the deformational/topographic front to the present Subandean Zone. This formation demonstrates selective trapping of coarse grain-size sediments in the wedge-top depocenter of the basin. This interpretation is further supported by coarsening- and thickening-upward trend and numerous growth structures in the Emborozu strata (Echavarria, et al., 2003).

Conclusion

Results from this basin study demonstrate (1) a marked upsection change in fluvial styles, fluctuations in accommodation space and sediment supply, regulated by basin subsidence. This is supported by a sourceward shift of the depositional system and shown by asymmetrical lateral and vertical variations in grain size and and facies changes. (2) general westward increase in formation thickness since Late Miocene (Yecua Formation) that is coupled with variations in rate of accommodation space. (2) The Cenozoic basin development in the Subandean Zone primarily was driven by compressional tectonics and secondarily by Late Late Miocene arid-to-humid climatic change. (3) Tectonically, the basin records the easterly propagation of the deformation front and foreland depocenter in response to loading, lithospheric flexure behavoir, and erosion by growing intra- and subandean fold- and thrust belt .

Acknowledgements

This study is supported by the DFG through its Sonderforschungbereich (SFB) 267 and Chaco S.A., Santa Cruz, Bolivia. I thank Oscar Aranibar, Fernando Alegria, and Nigel Robinson of Chaco S.A. for their logistical and material assistance. Spacial thanks to David Tuffino B., YPFB Santa Cruz, for providing some seismic lines and well reports.

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