6th International Symposium on Andean Geodynamics (ISAG 2005, Barcelona), Extended Abstracts: 734-737

The Late Cretaceous to upper Eocene clastic deposits in Ecuador: Sedimentary response to accretionary events

Jorge Toro-Álava [1,2] & Etienne Jaillard [2,3]

(1) Petroproducción, Av. 6 de Diciembre y Cañero, POBox 17-01-1006, Quito, Ecuador. jedutoro@hotmail.com
(2) LGCA-IRD, Maison des Géosciences, Université Joseph Fourier, BP 53, 38041 Grenoble Cedex 09, France
(3) IRD-UR 104, LMTG, 14 Av. Edouard Belin, 31400 Toulouse, France; Etienne.Jaillard@ujf-grenoble.fr

KEYWORDS : Ecuador, accretions, Cordillera Occidental, Subandean Zone, uplift, sedimentary response

INTRODUCTION

Ecuador has been submitted to repeated accretions of oceanic exotic terranes between latest Cretaceous and Late Paleocene, maybe Late Eocene times (*e.g.* Feininger and Bristow 1980, Reynaud et al. 1999, Kerr et al. 2002, Jaillard et al. 2004). These accretions occurred through subduction jam, without obduction, and resulted in the tectonic underplating of the oceanic material beneath the continental margin of Ecuador, thus generating and supporting the relief of the ecuadorian Andes (*e.g.* Guillier et al. 2001, Jaillard et al. 2002, Fig. 1). Our aim is to analyse the consequences of the accretions on uplift, erosion and deposition on the Ecuadorian margin, through the analysis of coeval clastic sediments, deposited in the cordilleran and eastern depocenters (Fig. 1).

SEDIMENTARY RECORD OF ACCRETIONS IN THE CORDILLERA OCCIDENTAL (COE)

Stratigraphic studies of the clastic deposits of western Ecuador allowed to define at least three accretionary events, expressed by unconformities between oceanic magmatic and sedimentary rocks devoided of detrital quartz, and continent deriving, quartz-bearing clastic deposits.

- A Late Campanian accretionary event (≈ 75-72 Ma) is expressed by (1) the deposition of syntectonic, coarse-grained, fan delta conglomerates on the continental margin of southern Ecuador and northern Peru (Quimas, Monte Grande, Casanga fms, Jaillard et al. 1999, Fig. 2), and (2) the unconformity of early Maastrichtian litharenitic turbidites (Yunguilla Gp *p.p.*) on the easternmost accreted oceanic terrane in Central Ecuador (Jaillard et al. 2004).

- The accretion of a new oceanic terrane occurred in Middle to Late Maastrichtian times (≈ 69-65 Ma), as evidenced by the unconformable deposition of marine shelf sandstones and turbidites of Early and Middle Paleocene age (Saquisilí Fm, Hughes et al. 1998, McCourt et al. 1998, Jaillard et al. 2004), on both the deformed, quartz-bearing, early Maastrichtian Yunguilla Gp, and intensely deformed radiolarian cherts and basalts (Jaillard et al. 2004). The latter are interpreted as belonging to the Colombian-Caribbean oceanic plateau of early Late Cretaceous age (Sinton et al. 1998, Kerr et al. 2002, Mamberti et al. 2003).

- In Southern coastal Ecuador, coarse-grained, quartz-bearing turbidites (Azúcar Gp) unconformably rest on pelagic cherts of early Late Paleocene age, and on Cretaceous basalts (Piñón Fm), both intensely deformed. Since the Azúcar Gp yielded latest Paleocene microfauna, the accretion of the Piñón terrane occurred in Late Paleocene times (≈ 58-56 Ma, Jaillard et al. 1995). In the COE, coarse-grained conglomerates (Gallo Rumi Mb) locally overly the Lower Saquisilí Fm, and are correlated with this accretionary event (Fig. 2).

- Finally, the coarsening- and shallowing-upward evolution of a Middle to Late Eocene clastic sequence of the Central Ecuador (Apagua and Rumi Cruz fms, Fig. 2) has been taken as evidence for the accretion of a last oceanic terrane (Macuchi island arc, Egüez 1986, Hughes and Pilatasig 2002). However, the Apagua sandstones do not overly the oceanic terrane, and the occurrence of Early to Middle Eocene shallow marine limestones overlying the Macuchi arc (Egüez 1986) rather suggests that the accretion occurred before the Eocene. Nevertehless, a tectonic contractional event did occur in late Middle to early Late Eocene times, and affected both the Macuchi arc and the neighbouring margin (Fig. 2).

Through time, clastic deposits display a clear evolution from arkosic arenites (Maastrichtian) to arkosic litharenites (Paleocene) and litharenites to sublitharenites (Middle Eocene), expressing a marked increase of the uplift and erosion of a crystalline basement (Toro and Jaillard 2005). Since supply is from the East or NE, the crystalline basement must be the Cordillera Real of Ecuador (CRE). During the Late Eocene, the petrography of clastic rocks evolved further toward arkosic litharenites, due to the reworking of the formerly deposited sediments. On the other hand, the depositional areas drastically reduced between the Maastrichtian and Paleocene, and continued reducing between the Paleocene and Eocene, exhibiting a westward retreat of the coastline (Toro and Jaillard 2005). These data indicate that the CRE underwent a progressive, although jerky, uplift between Late Campanian and Eocene times. Therefore, it may be expected that clastic sedimentation would be symetrical, on each side of the CRE (Fig. 1).

CORRELATIONS WITH EASTERN DEPOSITS (SUBANDEAN ZONE)

Stratigraphic studies (Jaillard et al. 1997) and identification of syntectonic markers allow to identify several hiatuses and unconformities in the present-day Subandean Zone (SAZ) and western part of the Oriente Basin.

- The lower Maastrichtian unconformity ($\approx$ 71 Ma, Fig. 1) separates Santonian marine shales (Upper Napo Fm) from overlying fine to coarse-grained fluvial to transitional sandstones (Basal Tena Fm, Jaillard et al. 1997, Barragán et al. this volume). The Basal Tena sandstones are interpreted as the sedimentary response the latest Campanian accretionary event registered in the COE (Fig. 2).

- The Late Maastrichtian unconformity separates claystones to fine sandstones of distal alluvial plain environment (Lower Tena Fm, Maastrichtian) from coarser sediments (Upper Tena Fm, Paleocene) (Jaillard et al. 1997). This unconformity is interpreted as related to the late Maastrichtian accretion recorded in the COE.

- The Late Paleocene unconformity ($\approx$ 54 Ma) is well expressed in the SAZ and farther East in well logs. There, coarse conglomerates of alluvial fan and braided stream origin, rich in clasts of subrounded red cherts and milky quartz (Lower Tiyuyacu Fm, Marocco et al. 1997), ascribed to the Early Eocene (Jaillard et al. 1997), unconformably overly the reddish fine sediments of the Upper Tena Fm (Fig. 2). This unconformity is thought to be generated by the Late Paleocene accretion recorded in the COE and the Coast.

Thus, accretions in western Ecuador seem to generate successively (1) erosional hiatuses interpreted as related to uplift, and (2) unconformable coarse-grained deposits. The unconformable sands or conglomerates of the SAZ are therefore interpreted as the delayed sedimentary response to the accretionary events occurring in western Ecuador. Because of still unprecise datings, the average lag time between accretion and sedimentation is difficult to determine but seems to be of the order of 2 to 4 Ma.

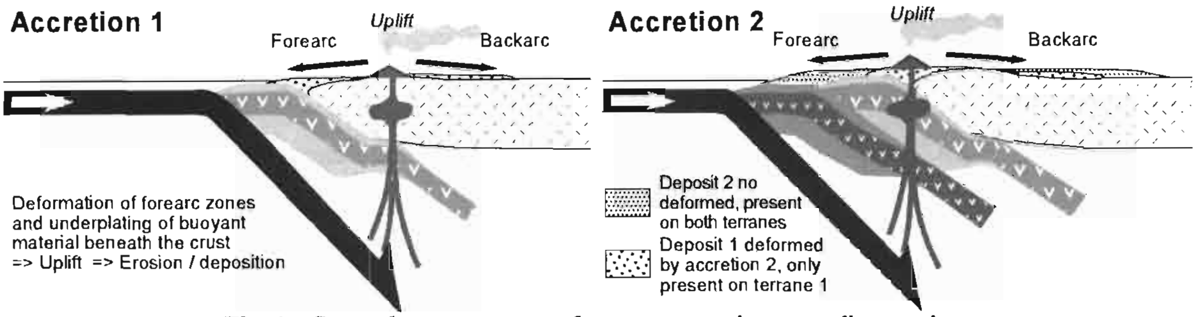


Fig. 1 : General consequences of terrane accretion on sedimentation

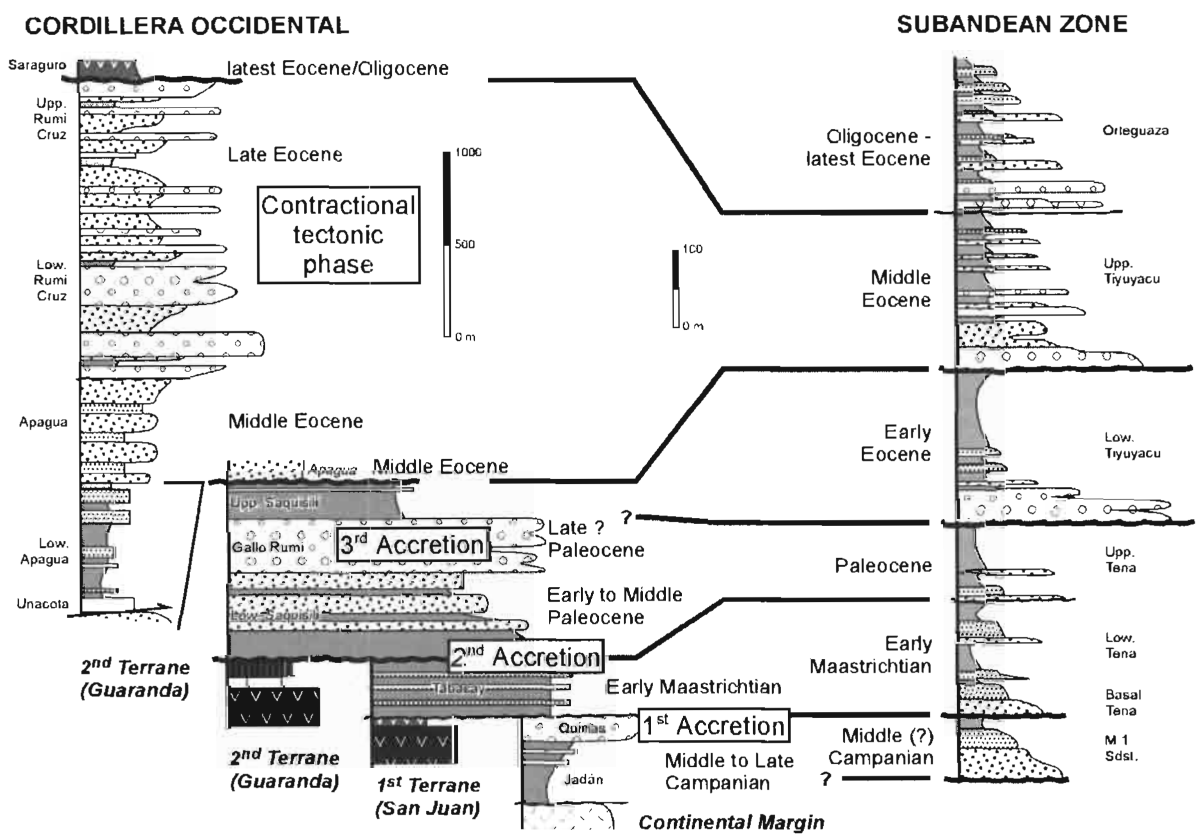
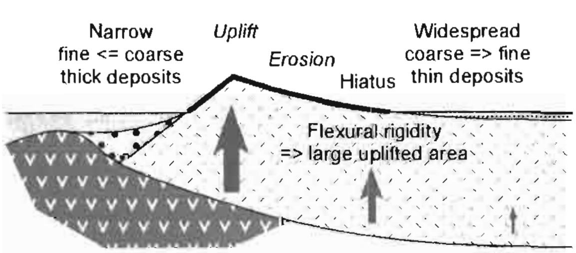


Fig. 2 : Correlations between clastic deposits of the Cordillera Occidental and Subandean Zone, showing the delay between accretions and unconformities in the Eastern areas.



Stage 1 (t_0): Immediate elastic reaction of the continental lithosphere induces uplift of large areas to the E. Narrow, deep tectonically controlled basins to the W.

Stage 2 (t_0+2 to 4 Ma): Erosional smoothing of slope, combined with delayed viscous reaction of the continental lithosphere, induce reduction of uplifted area and eastward retrogradation. Possible bypass to the W.

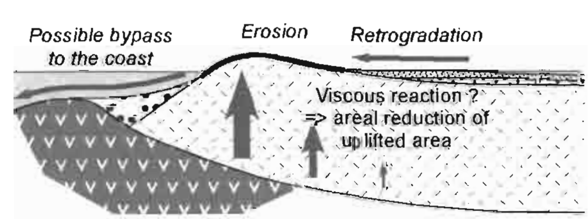


Fig. 3 : Model for crustal reaction and sedimentary response to accretion and underplating of a buoyant terrane

INTERPRETATION AND CONCLUSIONS

Accretion events coincide with uplift periods in the CRE. The erosion of the CRE triggered clastic deposition, both in the COE and in the SAZ, which record hiatuses and unconformities. In the SAZ however, deposition seems to be delayed with respect to the deposition in the COE.

We propose that this lag time is due to the fact that the accretion/underplating of oceanic terranes and related regional uplift would provoke the immediate clastic deposition between the accreted oceanic terrane and the CRE, in tectonically controlled basins, and an increase in the eastern slope of the CRE, inducing both enlargement of the bypass zone in the SAZ, and the Eastward migration of the depocenters (Fig. 3). Then, after erosion has incised the proximal slope, and reduced the average topographic gradient, coarse-grained West-deriving clastic deposits begin to retrograde toward the CRE, onlapping the eroded deposits, as formerly proposed for the sedimentary response to isostatic rebound subsequent to flexural subsidence (*e.g.* Heller et al. 1988). It is probable that long term, viscous reaction of the lithosphere causes subsidence of the proximal part of the basin (*i.e.* near the uplifted Cordillera), reinforcing the previous effects (Fig. 3).

In this model, the more proximal the section, the longer the hiatus encompassed by the unconformity. The same interpretation can be applied to compressional event occurring without accretions (Late Eocene (Fig. 2), Late Oligocene,...), since one of the main consequences of such contractional events was to run the accreted oceanic fragments beneath the continental margin, thus reinforcing their buoyancy effect, and triggering the uplift of the margin.

References

Barragán R., et al., 2005. *6th ISAG*, Ext. Abstract, IRD Publ., this volume.
Christophoul F., Baby P., Dávila C., 2002. *Tectonophysics*, **345**, 281-298.
Egüez A., 1986. *Unpublished thesis, University of Paris VI*, 116 p., Paris.
Feininger T, Bristow C.R.,1980. *Geol. Rundschau*, **69**, 849-874.
Guillier B., et al., 2001. *Geophys. Res. Lett.*, **28**, 3749-3752.
Heller P.L., Angevine C.L., Winslow N.S., Paola C., 1988. *Geology*, **16**, 501-504.
Hughes R.A., Bermúdez R., Espinel G., 1998. Mapa geológico de la Cordillera Occidental del Ecuador entre 0°-1°S, escala 1:200.000. CODIGEM-Min. Energ. Min.-BGS publs., Quito, Nottingham.
Hughes R.A., Pilatasig L.F., 2002. *Tectonophysics*, **345**, 29-48.
Jaillard E., et al., 1997. *Informe Convenio Orstom – Petroproducción*, Orstom – Petroproducción Publ., 164 p.
Jaillard E., Hérail G., Monfret T., Wörner G., 2002. *Tectonophysics*, **242**, 1-15.
Jaillard E., Ordoñez O., Suárez J., Toro J., Iza D., Lugo W., 2004. *J. South American Earth Sci.*, **17**, 49-58.
Kerr A.C., Aspden J.A., Tarney J., Pilatasig L.F., 2002. *J. Geol. Society, London*, **159**, 577-594.
Marocco R., et al., 1997. *VI Simp. Bolivar. Exploración Petrolera en Cuencas Subandinas*, Tomo I, Cartagena.
Mamberti M., Lapierre H., Bosch D., Ethien R., Jaillard É., Hernandez J., Polvé M., 2003. *Lithos*, **66**, 173-199.
McCourt W.J., et al., 1998. Mapa geológico de la Cordillera Occidental del Ecuador entre 1° - 2° S., escala 1/200.000. CODIGEM-Min. Energ. Min.-BGS publs., Quito.
Reynaud C., Jaillard, É., Lapierre, H., Mamberti, M., Mascle, G.H., 1999. *Tectonophysics*, **307**, 235-254.
Sinton C.W., Duncan R.A., Storey M., Lewis J., Estrada J.J., 1998. *Earth Planet. Science Lett.*, **155**, 221-235.
Toro-Alava J., Jaillard E., 2005. *Tectonophysics*, in press.