UPLIFT OF THE BOLIVIAN OROCLINE COASTAL AREAS BASED ON GEOMORPHOLOGIC EVOLUTION OF MARINE TERRACES AND ABRASION SURFACES: PRELIMINARY RESULTS

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INTRODUCTION

The southern Pacific coast morphology and especially the presence of marine surfaces gives information on the dynamics of Andean forearc evolution from the Neogene. Along most of the Southern Peru and Northern Chilean coasts, discontinuous uplifts are recorded by marine terraces and marine abrasion surfaces; they have thus preserved a record of eustatic sea level changes and the uplift history of the coastal area in the Andean forearc. One approach to study the tectonic history of the Andean forearc is to identify its effects in marine sedimentation or erosion patterns along the coastal area. To investigate these processes, the Neogene marine formations are studied in various coastal sections either in southern Peru, at Chala (15°50'S) and Ilo (17°32'S-17°48'S), situated above a steep subduction segment and at San Juan de Marcona (15°20'S), situated above the southern part of the Nazca ridge; or in Chile, from Tongoy (30°15'S) to Los Vilos (31°55'S), situated above a flat subduction segment *(Fig.1)*.

We chose various sites from each branch of the Arica bend in order to sample possibly different time spans during the Neogene and different response of the continental plate to the subduction process. Various studies were already undertaken on such problems either in Peru or Chile but mainly leaded to the datation of the 5th isotopic stage. So, differential GPS and cosmogenic datations are pursued in order to propose robust ages on these sites and subtract the effects of eustatic sea-level changes from local curves, identifying tectonic uplifts.

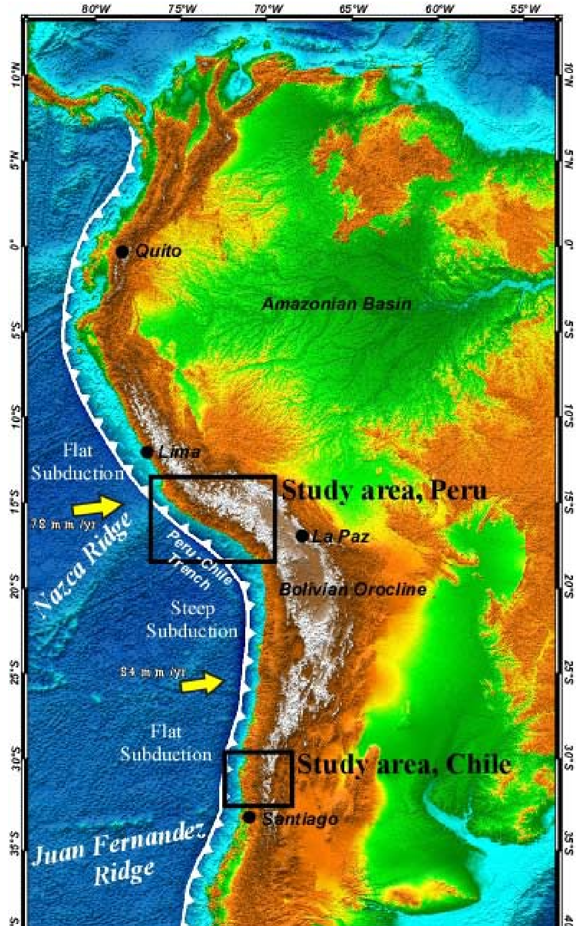

Fig.1. Location of the study areas

PREVIOUS MARINE TERRACE AGES

In Peru, at Chala, there are about 27 sea stands between 0 and 275 m asl (Goy et al., 1992).

- Terrace at +68 m would correspond at the 5th isotopic stage (125 kyr)
- Terrace at +121 m would correspond at the 7th isotopic stage
- Terrace at +168 m would correspond at the 9th isotopic stage
- Terrace at +184 m (or +200) would correspond at the 11th isotopic stage

At San Juan, there are more than 30 sea stands *(Fig.2a and b)*. The higher terraces reach about 780 m asl and hold late Pliocene fauna (After Devries in Macharé, 1987). The lower terrace chronostratigraphy is still debated. The 5th isotopic stage was successively assigned to: the +148m terrace (Hsu and Bloom, 1985; Osmond, 1987), the +110 m (Hsu and Wehmiller, 1987), the +90 m (Macharé, 1987) and the +65 m (Hsu, 1988; Hsu et al., 1989).

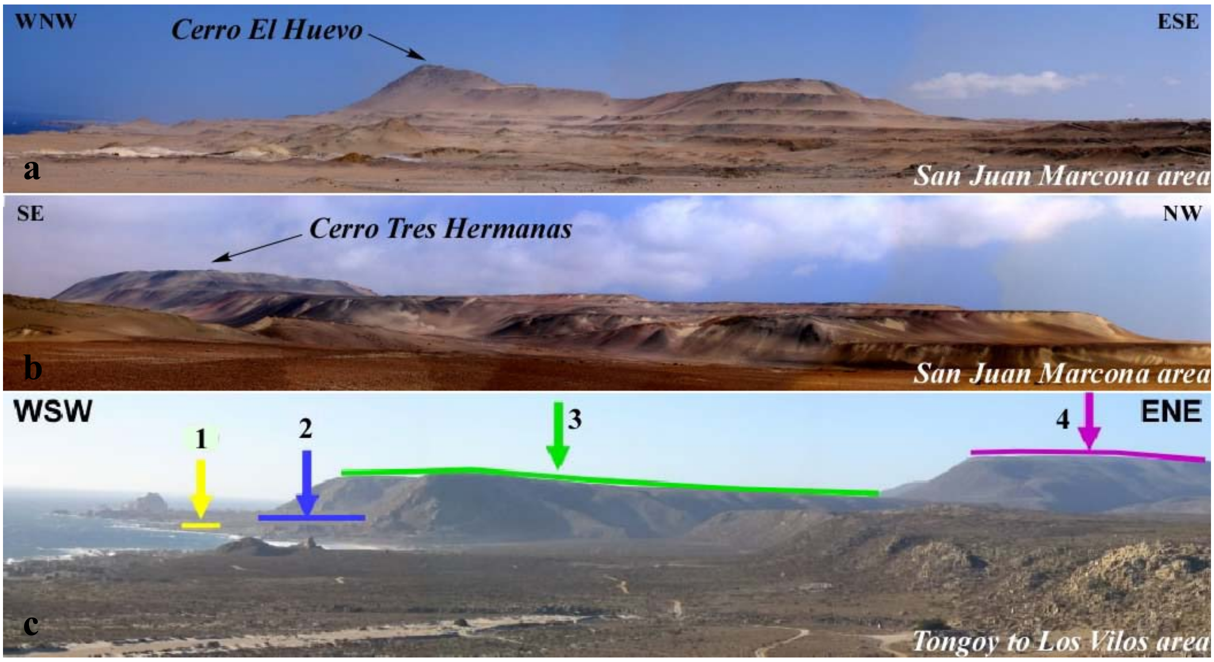

Fig.2. Panoramas of staircased marine terraces. a and b: San Juan de Marcona area in Peru. c: Altos de Talinay in Chile.

At Ilo, there are about 13 sea stands between 25 and 350 m asl (Ortlieb et al., 1996c). The Pampa del Palo terrace at +25 m would correspond at the 5th isotopic stage (125 Kyr).
So, the uplift rates for the southern Peru are, for the last 500 kyr (Goy et al., 1992), 460 mm/kyr at Chala and about 740 mm/kyr at San Juan de Marcona. At Ilo the uplift rate is about 220 mm/kyr for the last 300 kyr (Zazo et al., 1994) and 160 mm/kyr for the last 120 kyr (Ortlieb et al., 1996c).
In Chile *(Fig.2c)*, although several studies have been realized along the coast in order to obtain absolute or relative ages of marine terraces (Radtke, 1989; Leonard and Wehmiller, 1992; Ota and Paskoff, 1993; Ota et al., 1995; Ortlieb et al., 1996; Marquardt et al., 2004…), nothing has been done in this area. Moreover, four marine terraces have been dated in Bahia Coquimbo area, 80 Km to the north of Tongoy (Radtke, 1989; Leonard and Wehmiller, 1992), but the comparison between the two sites is not so obvious.

COSMOGENIC ISOTOPES METHOD

Samples analyses in laboratory (with the collaboration of the UCSC and the Lawrence Livermore National Laboratory) are presently under way and will hopefully yield robust and determinant ages. ^{10}Be production within the quartz varies according to latitude, elevation and sample depth ; its desintegration is about 1,5 Myr. In the study area, ^{10}Be use conditions are almost optimal; in the southern Peruvian desert, cosmogenic exposure is maximal due to the extremely arid conditions and the absence of vegetation, and low erosion. We chose this method in order to obtain absolute ages for each sampled terrace and because it is under application and calibration in the southern Peru on alluvial terraces (Hall et al., 2006, Tectonophysics, submitted).

In Peru, we sampled nine terraces along the coast: 5 at Chala, 3 at San Juan de Marcona and 1 at Ilo. At Chala, we sampled the +68 m (the 5th isotopic stage after Goy et al., 1992), the +101 m, the +165 m, the +214 m and the 249 m terrace. At San Juan de Marcona, we sampled the +169 m, the +214 m and the +294 m terrace and finally, at Ilo we sampled the +80 m terrace. There are four observable terraces along the Chilean coast, all of which we have sampled. The samples are currently processed and the first results will be available at the end of July 2006.

CAUSES OF THE TECTONIC AND UPLIFT OF THE COASTAL AREAS

Marine surfaces formation results from the interaction of eustatism and regional tectonic effects in the coastal zone. Eustatism alone cannot explain the present-day surface elevation since the higher see level reached in the Neogene is 15,5 Ma old and is only 150 m above the present see level (Hardenbol et al., 1998). In our study area, in contrast, the older abrasion surface is higher than 500 m asl (Altos de Talinay, Chile, about 30°25'S), evidencing the uplift of that part of the coast.

The fact that we observe marine surfaces north and south of the Arica bend shows that the subduction plane geometry is not directly responsible for the coastal uplift. The phenomenon that could explain the tectonic affecting the Peruvian and Chilean coasts may be either the underplating below the continental plate (Lallemand et al., 1994; Adam and Reuther, 2000), resulting in the formation of normal faults and in uplift or coseismic vertical motions, as observed in coralline algae records in the Antofagasta area (around 23°40'S, Ortlieb et al., 1996b), and the uplift of emerged marine platforms and of the coastal cliff along the Chilean coast (Marquardt et al., 2004; Quezada et al., 2005). Quezada et al. (2005) argue that the long-term uplift is positively correlated with the coseismic uplift, i.e., that the post seismic and interseismic subsidence of the coast does not completely compensate the uplift that occurs during earthquakes.

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