QUATERNARY EXTENSIONAL DEFORMATION AND RECENT VERTICAL MOTION ALONG THE CHILEAN COAST (BETWEEN 23°S and 47°S)

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INTRODUCTION

Along the South American Pacific margin are located various regions with uplifted Quaternary marine terraces in Ecuador, Peru and Chili for example. These coastal features result from the interaction between the subduction process and the continental deformation of the fore arc region. These South American coastal terraces are generally submitted to extensional deformation, mostly because they lie over the subducted plate without lateral constrains. However, the direction of the extensional deformation is variable. In areas of oblique convergence and relatively wide coastal zone (comprised between trench and Western Cordillera) the direction of extensional deformation stays orthogonal to the direction of plate convergence in Ecuador (Dumont *et al.* 1997) and in Southern Peru (Sébrier *et al.*, 1985). In Chile, where there is a narrow belt between the trench and the Main Cordillera, the vertical uplift motion of the coast line is documented by numerous Quaternary uplifted terraces. Moreover, the Coastal region is submitted to an extensional deformation normal to the margin and roughly parallel to the convergence direction. On the contrary, south of 33° Lat. S., the inner part of the fore arc (Central Depression) is submitted to a N-S compressional deformation (Lavenu and Cembrano, 1999) (Figure). North of 33° lat. S., between the Coastal range and the Main range, the Quaternary deformation is not documented.

Extensional deformation of the uplifted terraces

In the northern part of Chile (Mejillones Peninsula, Hornitos, Antofagasta) (Ortlieb *et al.*, 1996) Quaternary marine terraces indicate a regional uplift, and along the Atacama Fault Zone, numerous active faults show recent ruptures. The fault motion is essentially vertical with an E-W trending extensional deformation (Delouis, 1996). Nevertheless Armijo and Thiele (1990) described left lateral offsets.

In the coastal area of Caldera, Quaternary marine terraces also indicate a regional uplift linked to the subduction process (Ortlieb, 1995; Marquardt *et al.*, th is Symposium; Marquardt and Lavenu, this Symposium). Active crustal normal faults cut these Quaternary terraces (<220 000 años).Neotectonic field studies demostrate that the movement is essentially vertical, without lateral motion, and the extensional deformation direction is E-W trending.

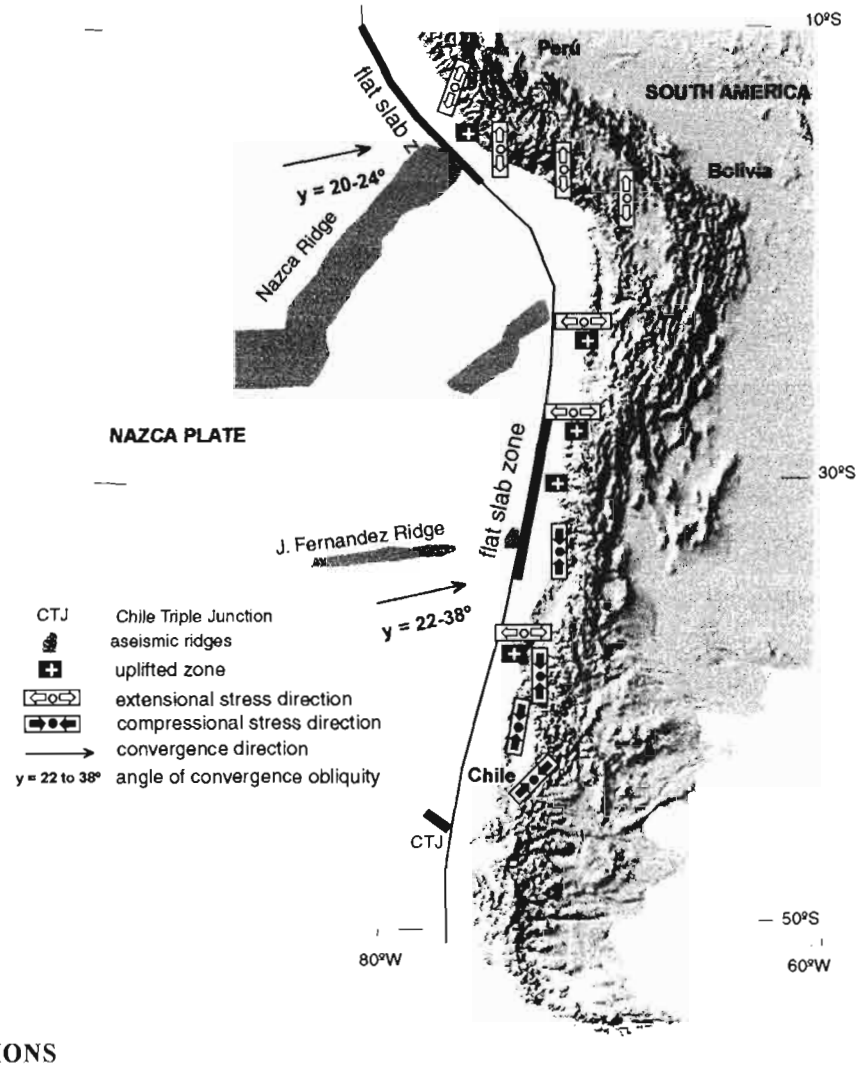
In the Río Limari/Altos de Talinay zone, uplifted Quaternary marine terraces (the oldest are dated in300 kyr) are also affected by normal faults, parallel to the coast and trending approximately N-S (Ota *et al.*, 1995).

In the Arauco Peninsula, southern part of Central Chile, field works permited to observe uplifted supposed Quaternary marine terraces. A kilometric normal fault, trending N10, affects the Plio-Quaternary deposits. This fault is the result of an ESE-WNW trending extensional deformation, similar to the Caldera and Mejillones deformations.

Seismotectonics and co- y/o post-seismic vertical motion

During this century Chile has been affected by one event with magnitude about 8, in average each ten years. The May 22, 1960 is one of the type example that reflects the strongly coupled seismogenic interplate contact associated with the subduction of the oceanic Nazca plate beneath the South American plate and it is the largest earthquake ever instrumentally recorded. In general, it is difficult to estimate the vertical and horizontal motions of the historical earthquakes that occurred along the Chilean trench, however, some of them has detailed reports: The 1822 Central Chile earthquake produced an uplift of 1.2 m and 0.9 m in the shoreline near Quintero and Valparaíso, respectively. The 1835 Concepción earthquake (Ms~8, 8¼) indicating that the Santa María Island (just north of the Arauco Peninsula) was uplifted by about 3 m, Quiriquina Island by 2.5 m and Talcahuano, in the bay of Concepción, by about 1.5 m (Barrientos, 1991). During the 1837 Valdivia earthquake (Ms~8), which is comparable with the 1575 and 1737 earthquakes and smaller than the 1960 one, crack openings were observed in Chiloé Island and Lemus Island was uplifted by about 2.5 m (Barrientos, 1991). The 1906 Valparaíso large earthquake (Ms=8.6, Gutenber and Richter, 1954) produced an uplift of the coast reaching between 40 and 50 cm in the Zapallar-Quintero (32.5°S) and Pichilemu-Llico (34.5°S) areas. There are reports that the 1928 Talca (Ms=8.4, Richter, 1958) produced an uplift in the coastal locality of Putú (35.3°S). There are no information that 1939 Chillán earthquake produced coastal elevation changes, agreeing well with the study of Campos and Kausel (1990) suggesting that this is a normal faulting event. The 1960 event ruptured more than 900 km, from the Arauco Peninsula (37.3°S) to the Taitao Peninsula (46.8°S); remarkable land level changes were observed over and area of 200x1000 km², the city of Valdivia subsided by about 2 m and the Guafo and Guamblin Islands were uplifted by more than 4 m (Plafker and Savage, 1970). Near the Laguna San Rafael dead forest attests of post-sismic subsidence and uplitf of this area. The 1985 Central Chile earthquake (Mw=8.1) generated a permanent uplift of the shoreline of 11 and 28 cm in Valparaíso and San Antonio (Comte *et al.*, 1986). The recent

1995 Antofagasta earthquake (Mw=8.0) had the maximum ground acceleration of 29%g in the E-W direction, and the maximum vertical offset recognized was 20 cm (Delouis et al., 1997). Over the zone of coastal uplift, E-W extension in the continental crust is expected.



CONCLUSIONS

The partition of the deformation across the plate boundary zone shows that the tectonic regime of the Quaternary is more complex than previously recognized (e.g. Dewey and Lamb, 1992). Along the coast and within the main range of Perú as well in the Bolivian Altiplano and Western Cordillera, the extensional deformation is interpreted as resulting from an acomodation of the rising topography, related to body forces. The E-W trending stress is $\sigma 3$ (Horizontal minimum principal stress, or tensional deviatoric stress), $\sigma 2$ is N-S trending (intermediate deviatoric stress) and $\sigma 1$ is vertical (maximum principal stress or compressional deviatoric stress) (Sébrier et al., 1985). Along the Chilean Coast, the Quaternary tectonic regime is extensional and of a ~ E-W direction. This deformation characterizes the westernmost portions of the continental forearc, close to the trench axis (~ 80 km). This deformation does

not appear to be directly linked to boundary forces due to the convergence, but could be the consequence of co- or post-seismic crustal bending with subduction-related earthquakes. It could be topographic accomodation to the uplift of this part of the coast (body force due to topography): $\sigma 3$ is striking E-W, $\sigma 2$ is striking N-S, and $\sigma 1$ is vertical. The uplifted terraces, located over a crustal bulge due to the subduction, are related to the E-W stretching.

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