# NAZCA - SOUTH AMERICA INTERACTION: REVIEW OF A 2D FLEXURAL ANALYSIS ALONG THE CENTRAL ANDEAN FOREARC.

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## INTRODUCTION

The Andean Cordillera is the classical example of mountain chains constructed by the convergence between oceanic and continental plates. Along the Central Andes segment (15° - 33.5°S), the orogen reaches its maximum height (> 6000 m) and width (600 km), presenting between 15° and 28°S the second biggest continental plateau of the Earth, the Altiplano-Puna. These high topographies are primarily compensated by a 60-70 km thick crustal root (i.e. Beck et al., 1996). The huge crustal volume of the Central Andes is thought to have been principally acquired through neogene-to-recent tectonic shortening of the backarc and foreland regions (Allmendinger et al., 1997; Kley et al., 1999). The subduction angle of the Nazca oceanic plate below the Altiplano-Puna plateau increases east and downward until 550-600 km depth, but south of these latitudes the deep angle (> 100 km depth) diminish gradually to flat subduction conditions (Cahill and Isacks, 1992), generating a volcanic arc gap between 28° and 33.5°S. These changes correlate with a slab age reduction, from 50 Ma under the Plateau to 40 Ma at the southern limit of the segment. At both limits, buoyant aseismic ridges are subducted; Nazca at 15°S and Juan Fernandez at 33.5°S. Interpretations of GPS observations along the margin (Klotz et al., 2001; Bevis et al., 2001) indicate that the thrust interface between Nazca and South America plates is 100% locked and <10% of the convergence is absorbed within the continent as lithospheric deformation. This result suggests that would be there a strong thermomechanical interaction between both plates in the forearc region. However, it is still poorly understood, which tectonic and mechanic influence has the forearc in the construction of the orogen and how is transferred the shortening component of convergence from the interplate contact *through* the forearc to the deformation front. In this context, I review the results of a flexural analysis applied to the Andean margin (Tassara y Yanez, 1996). In contrast to others flexural approaches (i.e. Steward and Watts, 1997), this analysis gives estimates on the flexural rigidity variations in the forearc and on along-strike gradients of horizontal compressive stress. These results are linked with tectonic variables and they contribute to best understand which roll play the forearc in the orogenic process of the Andes.

**METHODS AND RESULTS**

A 2D flexural analysis (see Turcotte and Schubert, 1982) was applied to 15 topographic and gravimetric profiles between 15° and 50°S (Tassara, 1997; Tassara and Yanez, 1996). Here are considered 10 of those profiles between 15° and 33.5°S. Each section is orthogonal to the principal trend of the Andes and runs from the Peru-Chile trench to the stable South American craton. The 2D flexural analysis developed assumes that the lithosphere is an elastic plate of variable thickness *Te* (effective elastic thickness), downward deflected under the vertical weight of topographic loads and horizontal tectonic stress *P*. Into the model, $P$=HCF*[$5*10^{12}$ N/m], with HCF (Horizontal Compression Factor) between 0 and 1. The inclusion of this factor in the analysis, generally not considered in traditional flexural approaches, respond to the high relative influence of compressive forces on flexure expected under conditions of very low rigidity below the mountain axis (Tassara and Yanez, 1996) and strong horizontal coupling between Nazca and South America plates. The Bouguer anomaly across each modelled section, was extracted from a grid produced by the Chilean Geological Survey (SERNAGEOMIN), and used as an actual signal of the Moho morphology and lithospheric deflection. A forward modelling of this signal for each section gives a *Te* profile and a value for HCF. The final model shows a good fit between actual and calculated Bouguer anomalies across each section, with residuals lower than ±25 mGal at 200 km long wavelength (Tassara, 1997). Nevertheless the forearc region shows relatively higher residuals than the orogen axis, suggesting that the quality of the estimates is here lower than there, it can be delineated the following first order characteristics of the flexural results:

1) For each section, *Te* increase drastically from <5 km on the western margin of the orogen to values of 50-70 km at the trench axis.
2) Maximum *Te* at the trench decreases along-strike, from ~70 km north of 28°S to ~50 km at 33.5°S.
3) To compare this variation, I have calculated for each section the average *Te* incremental gradient from the trench to the orogen ($\Delta Te$). Between 15° and 28°S $\Delta Te$ falls in the range 0.3 to 0.45, while between 28° and 33.5°S this value decreases gradually southward to 0.19.
4) These results suggests a southward decrease in the forearc rigidity.
5) HCF is 0.5 between 15° and 18°S, zero between 18° and 29°S, and increase gradually southward until 0.8 at 33.5°S.

**DISCUTION AND IMPLICATIONS**

The high rigidity of the forearc region is a direct consequence of the strong thermomechanical control exerted by the cold and rigid subducted plate on the rheological properties of the overriding continental edge, following thermal models proposed for the Andean margin (i.e. Olesckevich et al., 1999) that explains in this way the very low heat flow values reported for the forearc (Springer and Foster, 1998). The slab thermal control on the forearc is powered in the Andean context by the high mechanical coupling between both plates. In this thermomechanical frame, the rigid and coupled slab-forearc system can be seen as a solid indenter, pushing eastward and transferring, with minimal internal deformation, the non-seismic component of the convergence to the rheologially weakened regions of the orogen. Paleomagnetic evidences (Roperch et al., 2000; Lamb, 2001) indicates almost no tectonic rotations in the forearc since at least 10 Ma, supporting such a rigid mechanical behaviour. This active, indenter-like behaviour is consistent with the occurrence of high angle, high vertical throw compressive structures, described as the transition between the forearc and the Altiplano at 18°-20°S (i.e. Garcia et al., 1999).

The relevant influence of the oceanic plate thermal conditions on the rigidity of the forearc region, can be good appreciated in the clear along-strike correlation between the Nazca plate age at the trench and the *Te* values. The reduction of the age from 50 Ma at 28°S to 40 Ma at 33.5°S implies a ~30% increment of the heat flow derived from the oceanic slab (i.e. Turcotte and Schubert, 1982). Assuming that *Te* is inversely proportional to the heat flow, this variation can satisfactory explain the southward decrease in $\Delta Te$, without unconstrained changes in others rheological parameters (crust and mantle compositions or strain rate, see Burov and Diament, 1995).

In addition, the along-strike reduction of the Nazca plate age generates an increment of the slab buoyancy. This phenomena is linked with the southward increase of the mechanical coupling between both plates (Gutscher et al., 2000). This relationship is reinforced at the northern and southern limits of the Central Andes by the subduction of the buoyant Nazca and Juan Fernandez aseismic ridges. The total effect of the along-strike buoyancy and mechanical coupling variations on the horizontal stress transmitted from the plate interface through the continental margin, is clearly delineated by the northward and principally southward positive gradients in HCF values. The quantification presented here of such kind of gradients could help to constrain dynamical models of continental deformation.

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