Geodynamic impact of arrival and subduction of oblique aseismic ridges

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INTRODUCTION

The western margin of South America shows several aseismic ridges subducting under the South American Plate: the Cocos, Carnegie, Nazca (Inca) and Juan Fernández ridges (Fig.1). Subduction of these oceanic highs were frequently responsibilised for flat slab subduction (Pilger, 1981; Jarrard, 1986; Gutscher et al., 2000; van Hunen et al., 2002; among others) although nowadays some contributions argue against this previous hypothesis (Muñoz, 2005).

Since Bevis & Isacks (1984) and Cahill & Isacks (1992) little attention was payed to the relationship between flat slab and curvature of the continental margin. These authors established a direct relationship between margin curvature and flat slab subduction, suggesting that the varying continental bent margin exerts a strong control in the subduction geometry. According to this, the low subduction angle would be the result of geometric accommodation of the subducted oceanic crust.

Consequences of subduction of oblique aseismic ridges were commonly analized under the frame of shallow subduction. However, another consequences driven by subduction of these oblique oceanic features remains obscure: i.e. the change in strike of continental margins in order to reduce friction.

A plausible explanation for the origin of these major trend changes is presented in here based upon the geometrical analysis of present day asesimic ridges and its relationship with continental margins.

GEOMETRIC FEATURES

Locally straight South American active plate boundary contacts bathymetric highs normal to the ridge axis (Fig.1). Moreover, restoration of the Nazca (Inca) and Juan Fernández ridges to its arrival position demonstrate that those segments of the active margin affected by ridge subduction undergo flat slab subduction and show trend changes in the corresponding portions of the upper plate.

In the South American plate margin, a clear association between the presence of an aseismic ridge and other tectonic features such as the presence of a flat slab, a curved margin, a broken foreland (or changes in foreland deformation) and/or major wrenching structures, and relevant low depth seismicity can be observed (see Kley et al., 1999; Gutscher et al., 2002; Gutscher & Peacock, 2003).

The continental margin bend associated with the presence of a bathymetric high could represent the accommodation of the plate boundary system to obtain a minimum frictional force during oblique aseismic ridge subduction. Such tectonic rotation would lead deformation to transfer towards the foreland. Reactivation of ancient structures (wrench and thrusts) from the South American plate would trigger these changes (Ré et al., 2001, 2002; Japas et al., 2002a, 2002b).

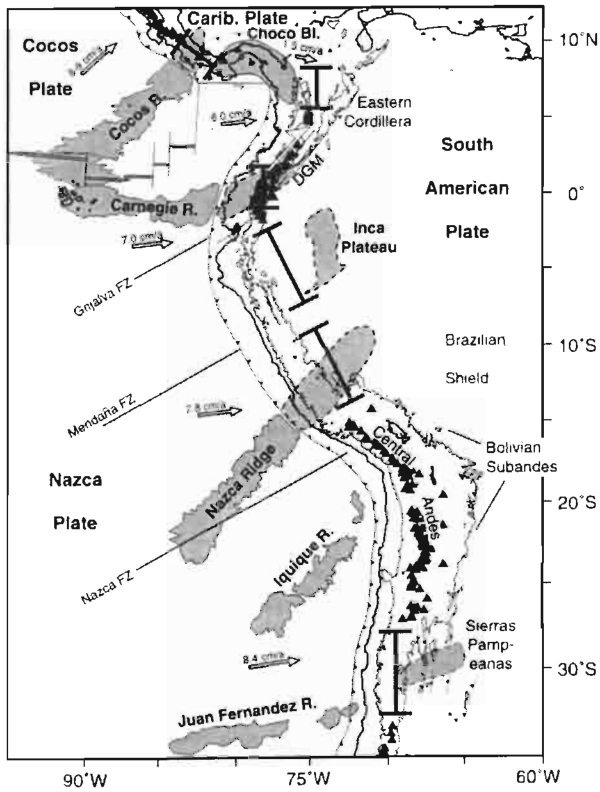

Fig. 1: Tectonic setting of the Andes margin (from Gutscher et al., 2000).

Convergence direction (A), ridge obliquity (or ridge axis trend, B) and the A-B relationship are the main factors controlling both margin deformation and ridge migration along the active boundary (M). Based on its mutual relationships five situations could be defined:

1) A // B ⊥ M

As the ridge is normal to the trench and parallel to the convergence direction, no ridge migration occurs along the continental boundary. This case could be equivalent to the situation modelled by Dominguez et al. (1998).

2) A // B ⊥ M

As convergence direction parallels the ridge axis, only local margin indentation would be expected (neither ridge migration nor widening of the upper plate affected zone)

3) A ⊥ B ⊥ M

In this situation, ridge migration induces continental margin deformation which would be constrained to an area equivalent to the width of the bathymetric high.

4) A ⊥ M ⊥ B

Obliquity of the ridge axis induces migration along continental boundary even when convergence direction were normal to the trench. The deformation zone increases its width as ridge migrates.

5) A ⊥ B ⊥ M

Aseismic ridges carried obliquely both to the trench and to the convergence direction produce an increasing width of the deformation zone as ridge migration progress.

DISCUSSION AND CONCLUSIONS

The arrival and subduction of an oblique asesimic ridge induces changes on the anisotropic upper plate margin. These changes tend to reduce frictional forces related to subduction of such a bathymetric high. Minimum friction arises when the ridge is subducted normal to the active plate boundary. Strike-slip and thrust motions along previous structures of the continental margin accommodate this geometric changes favoring its tectonic rotation, and transfer deformation into the foreland generating changes in its structural style (a broken foreland and major transpressive fault systems). Upper plate deformation, based on earthquake mechanisms (Gutscher et al., 2000), indicates strike-slip components in those flat slab segments which correspond to subduction of oblique aseismic ridges. In contrast, a lack of low depth seismicity is observed in areas in between these segments (Central Altiplano Plateau, Allmendinger et al., 1997) Reactivation of anisotropies depends on convergence direction.

Whereas B controls the strike of the deformed margin, A/B obliquity imposes the width of the rotated continental margin zone and defines the sense of migration of the aseismic ridge along the active plate boundary.

As the subduction of oblique aseismic ridges induces continental margin bending, the Bolivian Orocline could be considered the result of the subduction of the Nazca (Inca) and the Juan Fernández ridges.

Similar structural fabrics were also observed in comparable ancient active plate boundaries.

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