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Controls in Andean volume between 20°s and 48°s

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INTRODUCTION

The Andes show important variations in mean elevation related to variable orogenic volume, flexural behaviour of lower lithosphere as a function of thermal structure, and isostatic rebounds. Different morphostructural settings appear along its extension between 20 and 48 °S, reflecting specific gradients in shortening, with only minor and localized anomalies along strike (Kley *et al.*, 1999; Ramos *et al.*, 2004). All these tectonic variations are not only a consequence of Mesozoic pre-Andean geological history of the western margin of South America, which has influenced differential shortening through weakening of continental lithosphere during extensional back-arc processes as indicated by widespread Jurassic-Cretaceous shallow seas. This non-isotropic medium, which differentially yielded under compression has also been determined since Late Paleozoic rifting episodes, Proterozoic to Paleozoic amalgamation of western Gondwana, and a heterogeneous distribution of thick sedimentary prisms that are more easily detachable than the rest of the craton (Allmendinger and Gubbels, 1996; Ramos *et al.*, 2004). However, latitudinal variations in orogenic volume seem also to be the result of one to multiple Present tectonic controls. Strain partitioning, age and thickness of the subducted oceanic slab, coupling between plates associated with ocean buoyancy, velocity and convergence vector, and changes in the Benioff-zone geometry through time have been also invoked as controls in orogenic morphology of the Andean range (Chemenda *et al.*, 2000; Liu *et al.*, 1995). Recently, Lamb and Davis (2003) have proposed that high mountains are restricted to regions where climatic conditions are right, concluding that climate may help to focus local shear stress by inhibiting sediment thickness inside the trench. The trench sediment fill would control the dynamic of subduction by acting as lubricant between subducted plates and lowering shear stress. The higher volumes of the Andes would then be related to starved sections of the trench, that reaches as much as 8,055 m deep at 23°S, where shear stress reaches the highest values. The sediment-starved nature of the trench would be a direct consequence of the arid climate along the coast.

In this work we establish and discuss the different controls that are involved in generation of the Andean volume, separating those that are orogenic from those related with isostatic accommodations. This evaluation determined latitudinal bands in which more than one single factor would be operating, and anomalies to the general trend, which fit in the present frame of Andean dynamics.

DATA PROCESSING

In order to evaluate Lamb & Davis's hypothesis and find out the mechanisms that are important in the development of the different orogenic settings along strike, we have quantified and made a detailed study about the relation between several parameters i) the sediment thickness inside the trench, ii) orogenic volume iii) mean depth of the trench iv) age of subducted slab and v) precipitation rates from 20° to 48° south latitude at the western flank of the chain. Using different data sets and software packages, we have divided the study area in 12 blocks of 2° latitude each. Each block encompasses from the orogenic front at the eastern flank of the Andes to a point offshore in the Pacific Ocean, including the entire wide of the trench. We have also made topographic profiles across mid latitude of each block in order to show the relation between what we call "empty trenches" (trench's topography without sediments) and topography of the Andean chain.

The orogenic volume was calculated considering the volume above sea level using digital elevation models. Trench volume has been obtained by measuring the empty space below mean sea floor values.

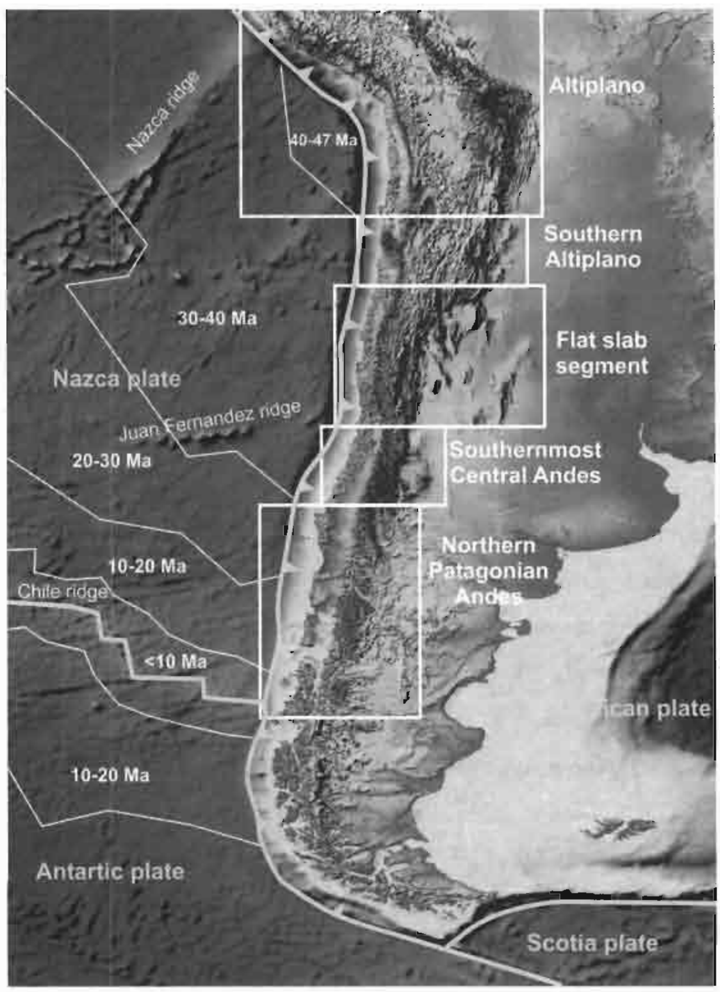

Figure 1: Graphic showing Andean morphology and tectonic setting in the study area.

RESULTS

With the only exception of two anomalies, centred at 27° and 33°S respectively, orogenic volume decreases from north to south while sediment thickness progressively increases all along the study area (20° to 48° S). The former anomaly would be the result of regional isostatic rebound in southernmost Altiplano as a consequence of delamination at 27°S, previously stated by several workers (Kay *et al.*, 1994). The latter, would be a consequence of anomalously thickened crust and subduction of extremely thick and therefore buoyant oceanic crust at 33° S.

In spite of an almost lack of sediments along the trench between 20° and 30° S, we have measured a progressive decrease in orogenic volume from north to south (figure 2). While sediment thickness remains constant and at minimum values, orogenic volume falls abruptly to the south, suggesting that other controls, and not precisely trench sediment fill, are influencing Andean volume.

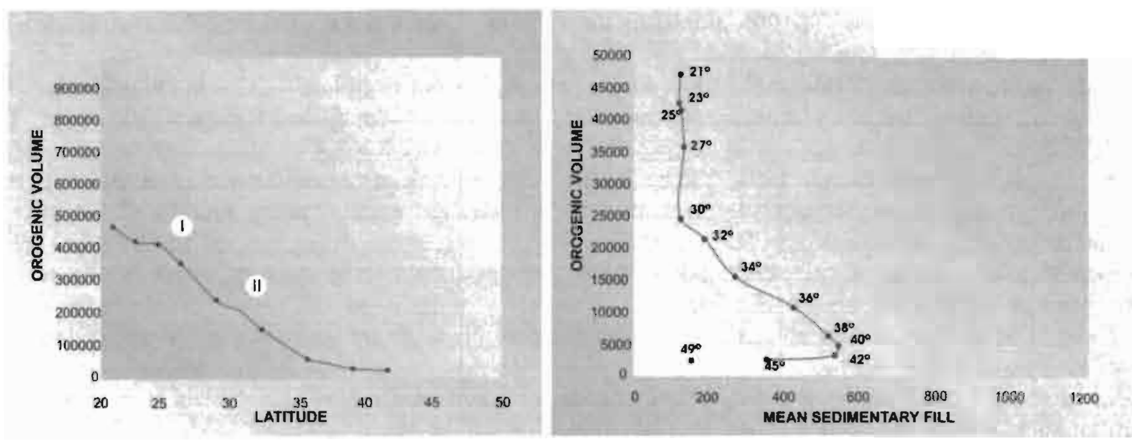

Figure 2: A) Orogenic volume vs. Latitude. It can be seen the two anomalies located between 27° (I) and 33° (II) degrees latitude, and a progressive-regional decline in volume (see text). B) Orogenic volume vs. mean sedimentary fill. From 20 to 30 °S mean sedimentary fill remains constant and at low values. To the south, orogenic volume and mean sedimentary fill follow an almost linear relation (see text).

Between 30° and 48° S, there is an almost linear correlation between orogenic volume and mean sedimentary thickness along the trench. Data show that Andean volume diminishes from north to south at the same time that sedimentary thickness increases. This inverse relation may be a consequence of an increase in lubricant effect due to a larger amount of trench sedimentary fill.

It is important to consider that the age of subducted slab becomes progressively older from Chilean ridge to the north (fig. 1). As stated by several authors, higher rates in slab pull forces and strain partitioning would be related to older oceanic crust (Chemeda *et al.*, 2000; Folguera and Ramos, 2000), explaining variations in orogenic volume along the area of almost empty trenches, where Lamb & Davis's hypothesis does not work.

CONCLUSIONS

Although results show that a relation between starved trench and higher orogenic volumes exists as previously stated by Lamb and Davis (2003), we have found that variations in Andean volume do not always respond to changes in trench sedimentary filling.

As stated above, some variations could be explained by local (anomaly I see figure 2) delamination (26-27° S) and by subduction of anomalous-thick oceanic slab (33° S), both contributing to local changes in orogenic volume.

We consider that between 30° and 46° S climatic-sedimentary supplies would become of first order range and Andean volume could have been influenced by climatic conditions. However, north of 30° S a linkage between trench sedimentary fill and volume variations does not exist. Further work needs to be done in order to establish wether variations in southern section are controlled by trench sedimentary fill or by other factors.

Through this study it is evident that variable orogenic volume along the Andes is probably the influence of multiple controls, perhaps with variable intensity and contrasting role along Andean strike.

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