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Long-wavelength subsidence in the Andean broken foreland: Sublithospheric controls on the sedimentation and topography of the Sierras Pampeanas?

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Introduction

Subsidence in retroarc foreland basins has been mostly explained by flexural analysis, in which a thrust belt load elastically bends the lithosphere producing depozones. Particularly in ancient examples, the methodology is based on matching the stratigraphic record, the deformational features that constitute a supracrustal load, and the mechanical properties of the crust. Yet, other controls ("hidden or sublithospheric loads") can act adding extra load. Thus the crustal bending generated only by supracrustal loads may be insufficient to explain the subsidence history, and an attempt to attribute all the subsidence to supracrustal loads results in overestimation of its true influence. Along a subduction margin, oceanic lithosphere subducting under a continent is also a load (Gurnis, 1992). Plausible physical processes in that setting include the effect of the thermal contrast between the slab and the overlying mantle. According to Mitrovica et al. (1989) this may result in up to 1 km of long-wavelength subsidence (dynamic subsidence). Densification of the lower crust (eclogitization, Leech, 2001) may also produce long-wavelength subsidence, particularly when the crustal thicknesses exceed 45 km. Nevertheless, demonstrating from the stratigraphic record that features deeper than the upper crust control subsidence is a challenging issue, still in debate (Liu and Nummedal, 2004).

In the Central Andes, flexural models have been extensively applied to account for the foreland basin subsidence (e.g. Toth et al., 1996; Cardozo and Jordan, 2001; DeCelles and Horton, 2003; among others). Few works have considered subcrustal influences, even though the South American plate has been complexly affected by a long-lasting history of subduction at least since the Early Paleozoic.

We present here surface and subsurface evidence in the Andean broken foreland of Argentina of long-wavelength subsidence, driven by processes occurring in the upper mantle or lower crust, which overlapped with the short-wavelength pattern of deformation, due to local basement thrusting.

Geological setting

The present study focuses on the Sierras Pampeanas (SP) region (27°-34° SL), southern Central Andes, within the broken foreland of western and central Argentina (Fig. 1). The region lies in the distal foreland on the Modern flat-slab segment, although its northern end is located in a transitional zone to normal subduction. The SP is characaterized by a set of ~N-S elongated basement ranges, bounded by doubly-vergent, high-angle faults affecting crystalline basement (Fig. 2). The basement highs are surrounded by Neogene basins, acknowledged as broken foreland or intramontane basins. They are entirely formed by a very thick (occasionally >10 km thick), non-marine, coarse- to fine-grained alluvial megasequence. From outcrop and subsurface, at least three major

southern SP (Fig. 4). Dynamic topography modeling predicts that when subsidence diminishes the zone will recover progressively, favoring surface uplift. If we presume that flat subduction migrated southward as a propagation wave through the SP (cf. Yañez et al., 2001; Kay and Mpodozis, 2002), then during the early Miocene dynamic subsidence would have affected the northern portion of the SP producing extra subsidence and a great thickness of alluvial sequences. These sequences were exposed later, when the dynamic wave migrated to its present position in the southern SP, provoking the regional subsidence pattern recorded by seismic velocity studies (Fromm et al., 2004). This progression may also explain the differences in altitudes, not easily accounted for basement deformation.

Eclogitization during crustal thickening (by thrusting or/and lower crustal flow) has a similar effect, driving regional subsidence by crustal densification. This densification could be associated with the arrival and interaction of the Juan Fernandez ridge in the SP region, affecting the northern SP in the early Miocene, and then the southern SP in the late Miocene-Pliocene. Both dynamic topography and eclogitization may have occurred, with overlapping consequences on the present topography and stratigraphy.

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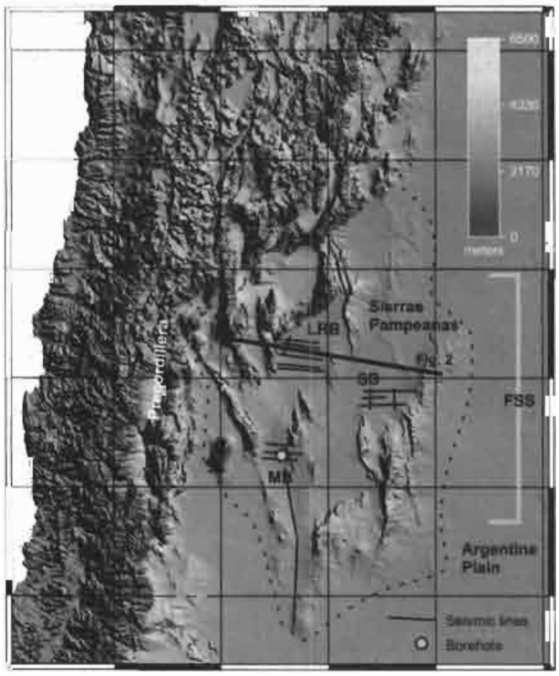
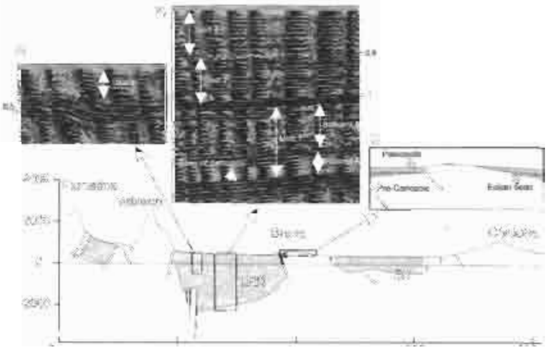
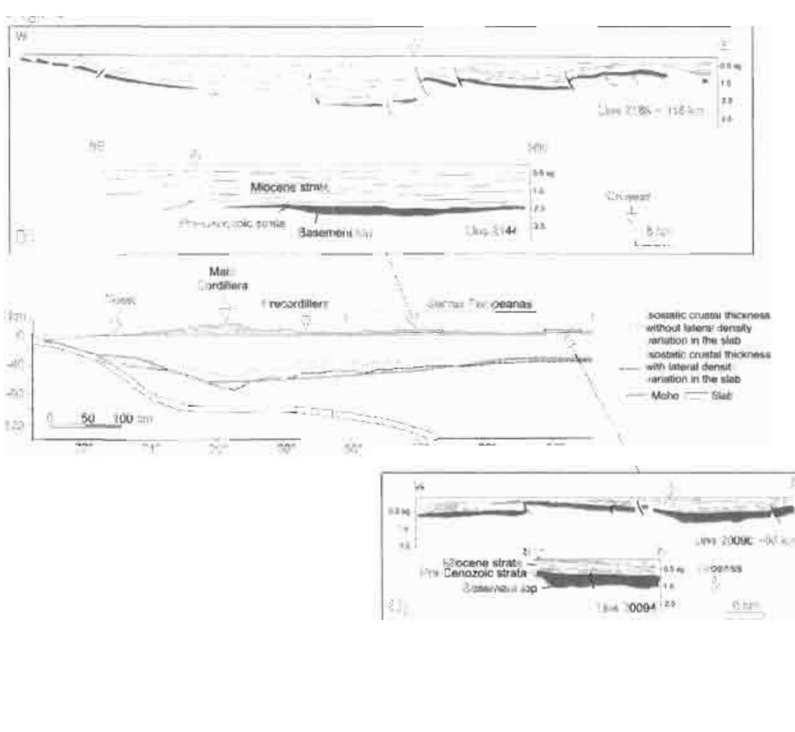
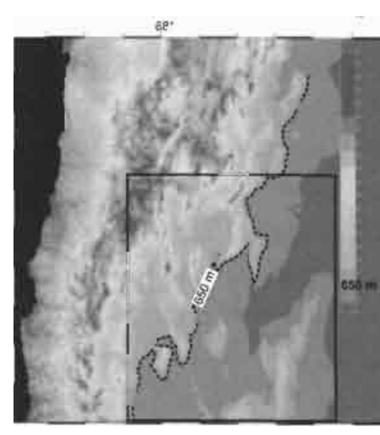

6500
4330
2170
0
meters
Sierras Pampeanas
LRB
Fig. 2
GB
FSS
Precordillera
MB
Argentine Plain
Seismic lines
Borehole


Pre-Cenozoic


Miocene strata
Basement top
Main Cordillera
Precordillera
Sierras Pampeanas
Isostatic crustal thickness without lateral density variation in the slab
Isostatic crustal thickness with lateral density variation in the slab
Moho
Slab
0 50 100 km
Miocene strata
Pre-Cenozoic strata
Basement top


68°
650 m
650 m