Geophysical Research Abstracts
Vol. 15, EGU2013-3739, 2013
EGU General Assembly 2013

Nazca plate subduction, mantle flow and Cordilleras formation

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The Nazca-South America convergence represents a unique natural laboratory to probe our understanding of subduction, mantle flow and stress coupling at Andean-type margins. Here, it is shown that the most fundamental balance of forces associated with the downgoing slab, the upper plates and the mantle can account for the Nazca plate motions, although it does not adequately explain the variations of the Cordilleran tectonics found along the ∼6000 km wide margin. Using three-dimensional numerical models it is shown that trench-parallel gradients in both the driving and resisting forces are an essential component of the force balance, and necessary to reproduce the macroscopic features observed. When along-trench buoyancy variations similar to the Nazca plate's are included, the slab dips and upper plate deformations observed in the Nazca slab, in the Cordilleras and South American continent interiors can be reproduced. The models show that gradients in the resisting shear force along the trench can be as relevant, as they modulate the trench retreat to form the concave Bolivian Orocline. Pressure gradients in the mantle follow the Nazca buoyancy gradients, and effectively rearrange the flow introducing a trench-parallel component, similar to what suggested by seismic anisotropy in this area. Although they introduce only secondary variations to the primary subduction and mantle flow dynamics, the regional features of the Nazca and South American plates exert a primary control at the margin-local scale. This suggests that far-field forces, e.g. from spreading Atlantic or large-scale convection, should play a minor role in the formation of the Cordilleras.