Geophysical Research Abstracts, Vol. 8, 09124, 2006
SRef-ID: 1607-7962/gra/EGU06-A-09124

Subduction mass balance, dynamic topography and its isostatic implications for the Central Andes

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The magnitude of surface dynamic topography generated by subduction mantle flow has been measured for retroarc foreland basins from stratigraphy using flexural back-stripping. Upper bounds of air-loaded retroarc dynamic topography measured from stratigraphy are 900 m at 500 km from the trench, 550 m at 1000 km from the trench, and 250 m at 1500 km from the trench. These upper bounds of subduction retroarc dynamic topography are consistent with oceanic residual bathymetric anomalies above subduction systems. Finite-element models of subduction driven mantle flow have been used to predict the magnitude and wavelength of surface retroarc dynamic topography. The observed amplitude and wavelength of subduction retroarc dynamic topography requires a layered mantle viscosity in which the viscosity rises by an order of magnitude across both the 410 and 660 km phase transitions. Finite-element subduction mantle flow models also predict substantial deviatoric stresses of the order of 50 MPa within the transition zone and top upper mantle for layered mantle viscosity models with viscosity increases across the 410 and 660 km phase transitions. Seismic rays sampling these deviatoric stresses are predicted to exhibit shear-wave splitting consistent with seismic observations.

Seismic studies suggest that the Central Andes are in approximate Airy isostatic equilibrium and as a consequence the Airy isostatic gravity anomaly provides an estimate of the deep sub-crustal gravity anomaly derived from subduction and related process. The Airy isostatic gravity anomaly for the Central Andes is of the order of 0 to 80 mgal. A comparison of this observed mantle residual gravity anomaly with that predicted by thermal models of the subducted Nazca plate under the Central Andes shows that the modelled gravity anomaly from the subduction process appears to be substantially greater than that observed by approximately 125 mgal. Finite-element models of subduction mantle flow predict a dynamic subsidence at the base of the Central Andean crust that deviates the crust from local isostasy by as much as 6-10 km and 4-6 km in the Eastern and Western Cordilleras respectively. The inclusion of this dynamic subsidence in the determination of the observed residual gravity anomaly greatly improves the fit between observed and predicted mantle residual gravity anomalies from the mantle over the Central Andes. This suggests that dynamic topography and the depression of the Moho beneath the Central Andes may be important in compensating part of the mass excess arising from the cold subducting slab. Apart from the slab itself, the most important body affecting the wavelength and amplitude of the dynamic topography is the asthenospheric wedge.