Geophysical Research Abstracts, Vol. 8, 01256, 2006
SRef-ID: 1607-7962/gra/EGU06-A-01256

Forearc tectonics and the subduction-earthquake cycle at Isla Santa María, Chile: Surface deformation at periods of 5, 5000, and 50.000 years

D. Melnick (1,2), B. Bookhagen (2,3), M. Moreno (1,4), H. P. Echtler (1), M. R. Strecker (2)

(1) GeoForschungZentrum Potsdam, Telegrafenberg, 14473 Potsdam, Germany, (2) Institut für Geowissenschaften, Universität Potsdam, Postfach 601553, 14415 Potsdam, Germany, (3) Department of Geological Sciences, University of California, Santa Barbara, California 93106, USA, (4) TIGO Geodetic Observatory, University of Concepción, 4036 Concepción, Chile (melnick@gfz-potsdam.de)

In order to gain insight into processes controlling the distribution of surface deformation during the earthquake cycle of subduction margins, we combine geological, geophysical, and geodetic data from the Arauco Bay area in south-central Chile (37˚S). The multidisciplinary data set allows comparing deformation processes at various timescales. At Isla Santa María, Charles Darwin measured between 2.4 and 3.0 m of coseismic uplift during the last great earthquake in 1835. An emerged abrasion platform remains today at this elevation around the island; the platform is steeply tilted to the east.

Radiocarbon dating of near-shore deposits exposed in sea cliffs show that coastal uplift and tilting at the island have been fairly steady over the last ∼50 kyr. The mean uplift rate is 2.1±0.4 m/ka and mean eastward-tilting rate is 0.032±0.018˚/ka. Luminescence dating of emergent strandlines in a coastal lowplain yields a similar average uplift rate during the past ∼5 kyr of 2.0±0.5 m/ka and tilting rate of 0.021±0.003˚/ka. Laser-total station topography of the strandline reveals that the wavelength and amplitude of the sequence oscillates with cycles of 1±0.2 ka, or 5±1 strandlines. These cycles are interpreted as transient periods dominated by slow continuous uplift, during which wider strandlines are formed, and periods dominated by meter-scale coseismic uplift, during which narrower strandlines with pronounced backswamps are formed.

Crustal seismicity registered by the ISSA2000 local network clusters immediately northeast of Isla Santa Maria. The data spans 5 month of observations between 1999 and 2000. About 92 events form a seaward-dipping alignment between 2 km depth and the plate interface at ∼15 km. Focal mechanisms are compatible with a NNE-striking W-dipping steep reverse fault. ENAP reflection-seismic profiles across the microseismicity cluster reveal blind W-dipping reverse faults and fault-related folds. These structures control the coastal geomorphology formed by elongated peninsulas, islands and bays, and tilting of the surfaces at Isla Santa María. The higher coseismic uplift occurred along these structures, and landforms of elevated long-term uplift rate, suggesting that slip on the plate interface thrust triggers movement on crustal faults, which in turn localize surface deformation. These faults are rooted in the plate interface.

The horizontal velocity field was derived from campaign and continuous GPS data spanning the last two to three years. The data shows ∼8 mm/a shortening across the cluster of crustal seismicity between Isla Santa María and Concepción. The principal axes of instantaneous strain derived from the GPS data around the Arauco Bay area show that shortening is nearly perpendicular to the seismically-active faults mapped from reflection profiles; this contrasts with areas farther north where shortening parallels plate convergence, suggesting that interseismic crustal faulting dominates surface deformation in the Arauco Bay area rather than deep plate looking. The cycles documented by the Holocene strandlines are interpreted as transient crustal faulting, overimposed to subduction earthquakes. Crustal faults in this coastal region seem to interplay with the subduction zone and the earthquake cycle.