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Sylvain Barbot

Postseismic Deformation in a High-Speed Collisional Context, Taiwan: Implication for the Lower-Crust Rheology

On 1999 September 21, the Mw 7.6 Chi-Chi earthquake ruptured a segment of the Chelungpu Fault, a frontal thrust fault of the Western Foothills of Taiwan, and a dominant kinematic boundary that accommodates the 8 cm/yr shortening between the Philippine Sea and the Eurasian plates. The stress perturbation induced by the rupture triggered an accelerated deformation across the island, which was recorded by a wide network of geodetic instruments. The analysis of more than ten years of three-component GPS data reveals a heterogeneous pattern of postseismic displacements, with relaxation times varying by up to a factor of ten or more, and anomalous high amplitudes of cumulative displacements along the Longitudinal Valley.

We interpret the spatio-temporal behavior of the transient deformation as the result of two dominant mechanisms of deformation involving afterslip on the Chelungpu thrust and the abutting décollement, and viscoelastic flow in the lower crust and in the mid-crust below the Central Range. Poroelastic rebound may have occurred but does not contribute noticeably to the large-scale deformation. We construct of physical model of deformation driven by coseismic stress change where afterslip and viscoelastic flow are fully coupled. The model is compatible with the shorter relaxation times observed in the near field, which are due to continued fault slip, and the longer characteristic relaxation times and the reversed polarity of vertical displacements found east of the Central Range. Our preferred model shows a viscosity of 0.5-1x10^19 Pa s at lower-crustal depths and 5x10^17 Pa s in the mid-crust below the Central Range, between 10 and 30 km depth. The low-viscosity block below the Central Range explains the mobility of the exhumed Eurasian crustal material in the hinterland by basal accretion and coincides with a region of low seismicity and high temperature anomaly inferred from thermo-chronology and surface heat flow.