Shallow coseismic slip deficit due to large (M7) strike-slip earthquakes

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Inversions of space geodetic data (in particular, Interferometric Synthetic Aperture Radar and Global Positioning System) from several large (moment magnitude ~7) strike-slip earthquakes indicate that coseismic slip in the middle of the seismogenic layer (at depth of 4—5 km) is systematically larger than slip at the Earth's surface. Fig. 1 shows an example of slip inversion from the April 4, 2010, M7.2 El Mayor (Mexico) earthquake, and Fig. 2 shows a compilation of slip inversions from severa well-documented events [Fialko et al., 2005], including our recent results for the El Mayor earthquake.

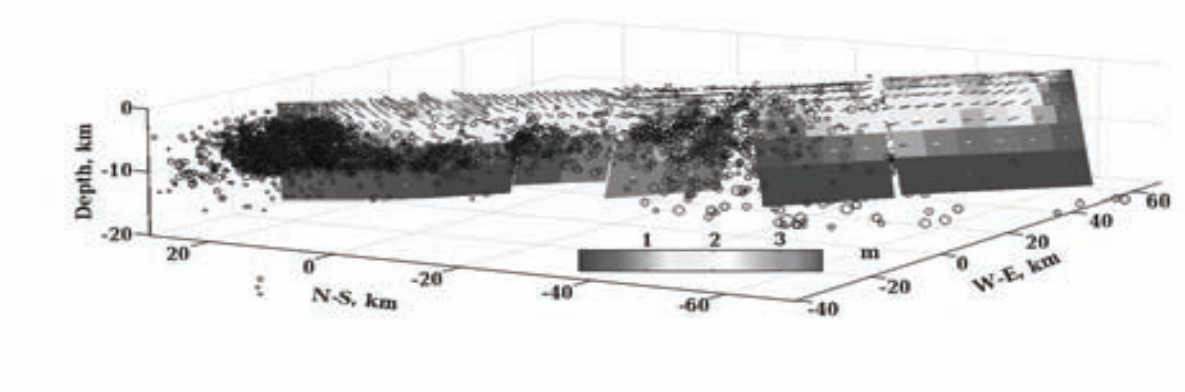

Fig. 1. Coseismic slip model of the El Mayor earthquake derived from inversion of InSAR and GPS Figure data. Colors denote the slip magnitude and arrows denote the sense of slip on the west side of the fault. Black circles denote precisely relocated hypocenters of aftershocks from the time period of 2 months following the mainshock (courtesy of Egill Hauksson).

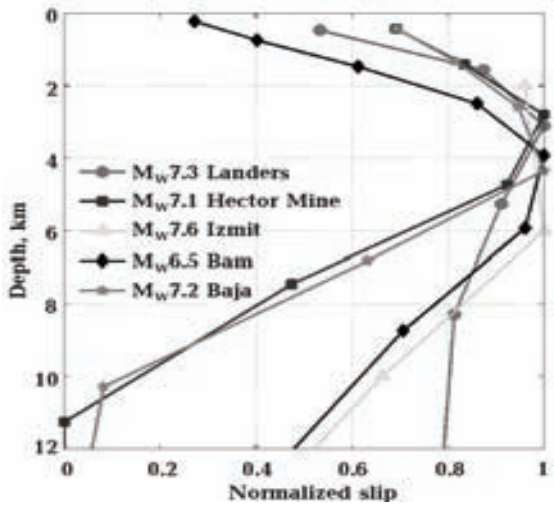

Fig. 2. Along-fault averaged distribution of slip for several large strike-slip earthquakes well constrained by the space geodetic data [Fialko et al., 2005]. The slip distribution from the El Mayor earthquake (magenta curve) follows the general pattern, with slip maximum in the middle of the seismogenic layer and shallow coseismic slip deficit.

This decrease in slip toward the surface, termed "shallow slip deficit", appears to be consistent with the idea that the uppermost brittle layer is velocity-strengthening, as suggested by experimental data [Marone, 1998; Scholz, 1998], there remain a ques-tion of how the coseismic slip deficit is accomфmo-dated throughout the earthquake cycle [Fialko et al., 2005]. To the best of our knowledge, events in-cluded in Fig. 2 were not associated with either shallow interseismic creep or robust shallow after-slip (in the amount sufficient to remove the coseis-mic slip deficit in the shallow crust) [Jacobs et al., 2002; Fialko, 2004; Fialko et al., 2005; Fielding et al., 2009]. We explore a possibility that the shallow slip deficit is associated with immature and/or infre-quently slipping faults and is caused by the bulk inelastic yielding of the host rocks in the shallow part of the brittle crust.

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