Lower crustal roots of active faults illuminated by volcanoes

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With the source region uniquely extended along with volcanoes, the 2008 Iwate-Miyagi Nairiku Earthquake gives us an extraordinary opportunity to investigate mechanical properties and structures of crustal roots of the active fault. As clearly shown by the aftershock locations and back ground seismicity, the basal depth of the seismogenic layer in this region is heterogeneous, affected by the local volcanic heat anomalies; importantly this basal variation and dipping fault setting greatly helps us to resolve the along-dip distribution of coseismic slip from the surface displacement. The existence proof of the localized shear zones below brittle upper crustal faults have been a major issue for studies of crustal, inland, active faults, given its effects on the stress accumulation mechanism in the upper crust and inter-seismic surface deformation. Here we show, based on an integrated earthquake source simulation incorporating inter-seismic and coseismic dynamics, and a geodetic observation using the SAR pixel matching, that a characteristic pattern of the observed coseismic surface displacement can be reasonably explained in terms of a typical loading condition due to localized shear deformation in lower crust before an earthquake. We further find that the strengths of the lower and upper crusts can be relatively inferred through the parameter that R=(T_u-T_o)/(T_o-T_l), where T_o is the regional shear stress level, T_u the spatial average of the sliding frictional strength of the upper crustal fault and T_l the long-term average of the lower crustal strength at which the shear zone creeps. This study suggests R~0 with positive T_o-T_l, implying, the importance of lower crustal shear zones for the loading mechanism of inland faults.